POWER

Volume 56 New York, December 12, 1922 *Number* 24

The A.S.M.E. An Organization of Service

"NONE of us liveth to himself alone." This is as true in the professions as it is in family and communal life.

The practitioner who secludes himself from other members of his profession, who liveth unto himself alone and loses himself in the details of his local activities will never get beyond Main Street.

Every good citizen should regard himself not as an individual out to make the best possible living for himself, but as a unit in the great Brotherhood of Man, directing his talents and his energy toward the success of the race in its struggle with its environment and in its onward and upward development. The more he does to this end, the more he will stand out among his fellows and the greater recognition he will gain.

It is true that many outstanding examples of acquisition owe their fortunes with their accruing privileges and prerogatives to customs and practices which bestow no service upon their fellowmen. It is true that many are tempted to emulate them rather than to win credit and preferment by real service.

Their success would impede rather than advance the general well-being.

No class is better circumstanced to carry out this idea of service than the engineer whose province it is to control and adapt the forces and materials of nature to the use and benefit of man.

And the engineer can do this through organized collective effort to better advantage than he can individually.

The American Society of Mechanical Engineers, which held its annual meeting last week, is one of the professional societies which has this idea of service foremost in mind. No organization can be greater than the ideals of its leaders, but service to the profession and through the profession to the public is the motivating idea in the administration of this society. It deserves the co-operation and support of every qualified member of the profession; not simply the joining of it and paying its dues, but by an active participation in the work which it is doing to help engineers help humanity.

Annual Meeting of A.S.M.E.

ALTHOUGH falling short of the usual registration —approximately 1,200 as compared with 1,854 last year—the annual meeting of the American Society of Mechanical Engineers, held at the Engineering Societies' Building, New York City, Dec. 4-7, made up for lack of numbers by the well-chosen program of technical papers and the helpful discussion at the sessions.

This year the presidential address took place on Monday evening instead of Tuesday evening as heretofore, President Kimball's subject being "National Leadership." An abstract of this appears elsewhere in this issue. After the address the tellers of election announced the selection of officers for the coming year. These were: President, John L. Harrington; vice-presidents, William H. Kenerson, Walter S. Finley, Jr., Earl F. Scott and Henry H. Vaughan; managers, A. G. Christie, James H. Herron and Roy V. Wright; treasurer, William H. Wiley. This was followed by the reception and dance.

From the viewpoint of the *Power* reader the keynote sessions were the symposium on stokers and the power session on Thursday morning, where the subjects of feed-water heating, high steam pressures and superheat were spiritedly discussed.

Several joint sessions were held with outside societies, one with the American Society of Refrigerating Engineers on Monday, another with the American Economic Association on Wednesday evening; a third on Safety Engineering under the auspices of the Committee on Safety Codes and the American Society of Safety Engineers; and a fourth on Standardization with the American Engineering Standards Committee.

Engineering and Economics

In an address at the latter meeting Prof. Wesley C. Mitchell, of Columbia University, advocated among much needed improvements, the stabilizing of the monetary standard, controlling the business cycle and allowing production to be organized in units large enough to attain maximum industrial efficiency, while safeguarding the community against high prices. American engineers, he thought, would make constructive contributions toward the solution of many of the nation's industrial problems, and the need for further progress in the technical arts of production is not lessened by the marvels of electricity and automatic machinery.

E. M. Herr, president of the Westinghouse Electric & Manufacturing Co., delivered the second address of the evening under the title of "The Human Problem in Industry." He urged the substitution of the rule of reason and intelligence for force in an effort to restore the freedom of the individual whether employer or employee.

"The principal new thing about the human problem in industry," continued Mr. Herr, "is that industry is now conducted on a large scale—larger than ever known before—and that the problem has been intensified not only by factory employment and all that goes with it, but by the greatly increased size of manufacturing establishments, by the concentration of population in cities having a large foreign element often of radical tendencies, and by the insecurity of employment, in which business cycles play a large part. Furthermore, a very large number of people are now entirely dependent upon industrial operations, as those employed in manufacturing in early days were not.

"These concrete things all conspire to produce conditions which cause what is perhaps the greatest problem in the industrial relations of today; that is, the underlying labor unrest and distrust, born of fear and misunderstanding, fear of coercion, unemployment and sickness, and a lack of mutual confidence as between employer and employee. There is more liberty and consideration for the workers than has ever been known before, and with it has come to the workers the greater vision of what they believe should belong to them in welfare and happiness. The social responsibility of management is being emphasized as never before.

"Of first importance is the responsibility of management in its broadest sense. The awakened worker of today, more sensitive than his predecessors, intelligent, critical and perhaps irritable, must be convinced of the ability of management as well as its good faith, and in extreme cases even of the necessity of its being."

Many large industries, according to Mr. Herr, are establishing personnel departments to bring about essential contact with the workers. He pleaded for an intelligent extension of this function, regretting that some companies have curtailed it in times of depression when both they and the men need it most.

Secretary Rice Reports on South American Trip

Calvin Rice, secretary of the American Society of Mechanical Engineers, reported on his trip to the International Engineering Congress at Rio Janeiro, Brazil.

He stated that as a representative not only of the Society, but also of Mr. Hoover, Secretary of Commerce, he participated in the Congress along with other American engineers. To the activity of the latter Mr. Rice attributed the final success of the meeting. He announced that Leroy Havens, editor of the *International Ingenieria* had been made secretary of the Congress.

The speaker emphasized that throughout his visits to the several South American countries he was impressed with the fact that the engineering profession was held in the highest esteem. He found that American engineers located in these countries had by their ability and deportment been placed in a position of high regard by these countries.

Mr. Rice was impressed with the wonderful possibilities of the South American countries as well as with the developments that had already taken place. In his estimation South America holds forth most attractive markets for American engineering talents and machinery.

The engineers of Rio de Janeiro, he said, have pledged themselves to pool their respective codes and private collections of technical words and phrases used in Brazil. Similar pledges have been obtained from engineering bodies in other countries. The result will be the development of a vocabulary of technical words and phrases in Portuguese and Spanish.

The interest taken in world events by the South Americans was brought out. In Brazil daily papers, instead of the practice of North American dailies of carrying all the murders, etc., on the front page, devoted the first two pages to foreign news. Even in

interior cities in the Andes foreign news appeared regularly in the daily and weekly press. In this respect he felt that they were in advance of the United States.

Mr. Rice expressed the belief that the Engineering Congress will have far-reaching results in drawing the two Americas together, at least in an engineering sense.

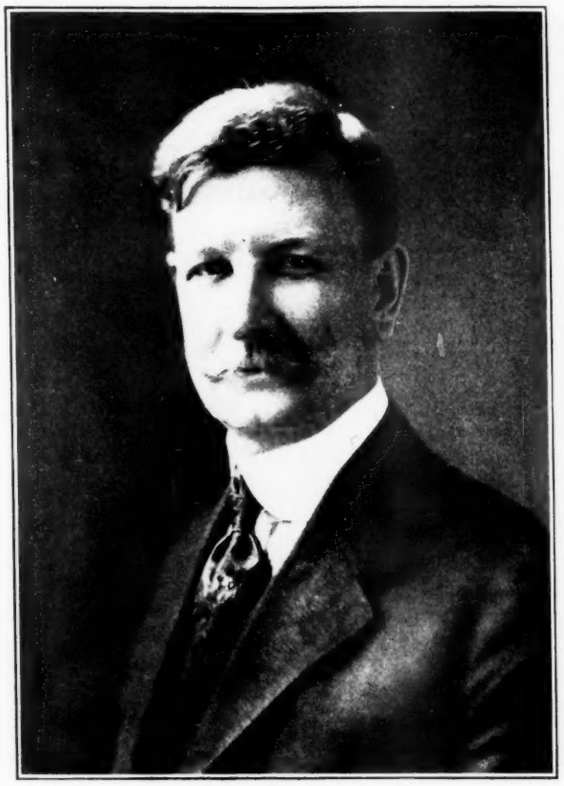
Work of Federated Engineering Council

L. W. Wallace, secretary of the Federated Engineering Council, Washington, D. C., outlined at some length the various activities of the Federated Engineering Societies. He felt that the Federation had been of great benefit not only to the members of the several societies, but to the country as well.

This country has spent millions of dollars on river improvement; for example, $161,000,000 on the Mississippi without there being any well-defined understanding of the science of flood and stream control. For this reason the Federation has had introduced into Congress a bill authorizing the establishment of a hydraulic laboratory where the necessary investigations can be taken up.

A second piece of legislation approved of by the Council is the creation of a commission of engineers to study the Muscle Shoals project. Mr. Wallace stated that so far no one either in public or civil life understood the entire Muscle Shoals development and possibilities and most opinions on the subject were by no means impartial.

He felt that the report on "Waste in Industries" was by far the most important work undertaken by the Council. The results had been translated into several languages. The industrial world had reacted favorably to the report, and many firms had been able to reduce their manufacturing costs by reason of the facts revealed by the report; as example, there have been over sixty different sizes and grades of paving brick made and recently the number was reduced to two or three.



JOHN LYLE HARRINGTON

Newly Elected President, A. S. M. E.

Mr. Harrington is a native of Kansas City, a graduate of the University of Kansas with the degrees of A.B., B.S. and C.E., and later received his M.S. from McGill University. He was for many years associated with the well-known civil engineer, J. A. L. Waddell, and is now a member of the firm of Harrington, Howard and Ash, consulting engineers. His specialty has been bridges and structural work. He joined the society in 1902 and served as a vice-president last year.

Power Test Codes

At the meeting of the Committee on Power Test Codes on Monday afternoon the committee formulating the codes for testing steam boilers reported that the differences which had existed with regard to separating the boiler and furnace efficiencies had been harmonized, and that the code was now satisfactory to all of the members of the committee. Its publication for further discussion was authorized.

The Committee on Fuels announced that its code was ready for distribution in tentative form. Prof. L. P. Breckenridge presented his resignation as chairman of this sub-committee, and at a subsequent meeting Prof. W. J. Wohlenberg was elected in his place. J. W. Parker resigned the chairmanship of Individual Committee No. 6, which has nearly completed the formulation of the Test Code for Steam Turbines, and C. Harold Berry was elected to fill the vacancy.

The Code for Locomotives and that for Gas Producers are now complete, and will soon be issued in tentative printed form for comment and criticism. W. F. Kiesel, Jr., was added to the Committee on Locomotive Codes as representative of the American Railway Association.

The Code for Internal Combustion Engines was approved for printing in the technical press for criticism, also Chapters I and II entitled General Considerations of the Report of the Committee on Instruments and Apparatus. Chapter III, entitled Temperature Measurements, is completed, and will shortly be issued in tentative form.

The test Code for Reciprocating Pumps and that for Feed Water Heaters were fully discussed at the public hearing and commended to the Council for adoption after the few changes suggested had been made as the recommended practice of the profession.

Among the entertainment features was a smoker on Tuesday evening, a tea and reception for the ladies at the Society headquarters on Wednesday afternoon and a dinner dance at the Hotel Astor on Thursday evening.

The excursion program included trips to the Wheeler Condenser and Engineering Co., Carteret, N. J., the new Hell Gate Station of the United Electric Light and Power Co., Automatic Station, Pennsylvania Exchange of the New York Telephone Co., the New York Telephone Company's radio broadcasting station, the oil burning plant of the Metropolitan Life Co. and the Ritz-Carlton Hotel, a visit to the battleship "Maryland," and on Thursday an inspection of the publishing plant of the McGraw-Hill Company. At the last named plant luncheon was served, after which the delegates were taken to the Power Exposition at the Grand Central Palace.

A demonstration was also witnessed of the new Christie tanker gun mount. This is designed to operate on either land or water, the water demonstration being made by a trip across the Hudson River. There were also special excursions for the ladies.

National Leadership

BY DEXTER S. KIMBALL
Retiring President of the A. S. M. E.

THE benefits that have accrued to all classes in modern civilization are beyond question and are more apparent when comparison is made either with older forms of civilization, or even with existing handicraft nations. The general level of physical comfort and education as seen in modern nations is unquestionably higher than has ever before been attained. Nevertheless, no single class of people is satisfied with its position in the nation, and there is a deep feeling of unrest and discontent among those workers who actually produce the comforts of life. A multitude of reasons are advanced for this dissatisfaction and a multitude of remedies are offered for its mitigation. It is obvious, however, from these suggested remedies that much if not most of these troubles have their roots in the industrial system under which we live.

This charge that modern civilization is a failure or at least no improvement upon former civilizations, is, or should be, of peculiar interest to the engineer, using this term in its widest sense to include all industrial workers who use the scientific method. For modern civilization is largely what he has made it, and the civilization of the future will be largely what he wishes it to be. It is too much, of course, to claim that the engineer, unaided, can solve these difficult problems, but it is undoubtedly true that if he will direct his energies to the problem of the distribution of wealth as earnestly as he has devoted them to its production, he can make a contribution to industrial economics that will be exceedingly hopeful.

MODERN civilization has created economic problems requiring a new form of leadership that offers a challenge and an opportunty for service which the engineer may not refuse.

Furthermore, it should be noted that the efforts of the engineer are no longer confined to the design and actual production of commodities. The principles of mass production that have so greatly reduced the cost of commodities he has now quite fully developed. The wide application of the principles of mass production has been made possible by mass financing, the work of the financier. The engineer, in turn, is now developing the principles of mass management, and his contributions to the philosophy of management are already noteworthy.

It will be freely conceded that the preparation of the engineer for these new duties is far from adequate, and two of his shortcomings stand out conspicuously. The first is his lack of knowledge of the economic principles of industry and commerce. This need in the equipment of the engineer is now fully recognized, and in a fair way to be remedied. All first-class engineering colleges now prescribe more or less economic study and students of engineering recognize this study as a necessary part of their mental equipment.

Another important weakness in the mental processes of the engineer is his lack of knowledge of human nature and, worse still, his lack of sympathy with human problems. He is by nature a constructive individualist and usually impatient to obtain results; and, as a consequence, impatient of any obstruction, human or physical, that stands in the way.

Over against these weaknesses must be placed certain inherent qualities that strengthen his claim to industrial leadership. He is, as a class, essentially honest. His entire training and professional experience are such as to demand honesty of thought and purpose in all of his transactions.

And last, but most important, the engineer has command of the scientific method of attacking problems. With this he has practically solved the problem of production and is now rapidly rebuilding the field of administration. Is it unreasonable to suppose that he cannot make a great contribution to the problem of the distribution of wealth if he attacks this problem in the same wholehearted manner that he has applied himself to these other fields of activity?

All thinking men who know anything about industry agree that we are sadly in need of a new form of industrial leadership, but the source of this new leadership does not seem to be clear. And it should be noted that future industrial leadership will be closely associated with political leadership, so closely are the problems of industry linked with political administration. The first form of national leadership was the military type, the rule of the strong man. This extreme form of leadership still prevails in some countries. In modern democracies military rule has been succeeded by what may be termed legal government. Today our social, political and industrial activities are governed by a very comprehensive code of legal regulations that rest upon precedent and upon the opinions of eminent jurists sometimes affirmed and reaffirmed many times. The legal method and the legal mind, however, are usually backward looking in their processes.

There remain for consideration two other types of mind from which a new industrial leadership may come; namely, the business or financial type, and the scientific type. The business type of mind with the aid and counsel of the legal and engineering fraternities has built up modern industry as we now see it. There can be little doubt as to the ability of this type of mind to plan and direct the larger aspects of industry along existing lines. One weakness lies in its apparent inability to appreciate or rather to acknowledge that a new industrial day has dawned in which industry is being viewed more and more as the support of human life and not as a means of producing private, corporate, or state profits. Another weakness is its lack of technical knowledge of modern industry. As industry becomes more and more complex, the business man is compelled to depend more and more upon the engineer for advice and knowledge. It is this very phase of modern industry that is rapidly forcing the rôle of industrial manager upon the engineer.

No one would presume to say that the engineer alone can solve the industrial riddle, but it is clear that he can make a very great contribution to the solution. And it becomes increasingly clear that hope of a solution rests with the two groups just discussed.

Symposium on Stokers

THIS session was held on Wednesday morning under the joint auspices of the Fuels Division and the Stoker Manufacturers' Association, with L. P. Breckenridge as chairman. The formal papers covered the three general types of mechanical stokers; namely, chain grate, overfeed and underfeed.

Development and Use of Modern Chain Grate

By T. A. Marsh,
Chief Engineer, Green Engineering Co.

Chain grates embody the principles of progressive combustion. As coal is fed into the furnace, the moisture is vaporized; then the volatiles are distilled and burned in suspension, followed by the burning of fixed carbon. Finally, the ash is discharged over the rear and the air space of the grate is cleaned automatically for a repetition of the process.

Free-burning coals burn best when the fuel bed is undisturbed; coking coals demand fuel-bed agitation. High-ash coals demand continuous scavenging of refuse from the grate; with low-ash coals this is not necessary. Clinkering coals must not be agitated, or clinker formations will result. With non-clinkering coal agitation has a less detrimental effect.

Chain grates were first developed to burn high-volatile, free-burning, high-ash, clinkering coals, and for such fuel they offer in best form the specific combustion treatment demanded. The fuel bed is undisturbed, and the ash is discharged continuously from the grates. The development resulting in the modern chain grate has been gradual but definite, and has involved the successful burning of many coals having widely different characteristics.

In determining the ultimate value of any stoker, there always must be a common-sense balance between maintenance, efficiency and capacity. With two-thirds of the grate area out of the furnace and with a simple driving mechanism, maintenance of the chain grate has been low. Small auxiliary power requirements make all results obtained practically net, so that efforts to improve efficiency have been directed toward the elimination of excess air and the reduction of furnace and ashpit losses.

Air leakage has been reduced by the perfection of adjustable ledge plates along the sides of the stoker, and simple adjustment at the rear is provided by the modern fuel retarder which is installed in connection with a fixed water-back and bridge wall. This device can be raised or lowered to make a definite air seal with the fuel bed. Sifting of the coal through the grate has been reduced to 1 or 2 per cent of the coal fired by the use of longitudinal skids to carry the chain in place of the cross-rollers formerly employed.

Within the last ten years quadrupling the furnace volume has reduced greatly the losses due to unburned hydrocarbons. These improved furnaces, together with higher drafts, longer high-set arches, water-backs and the fuel retarder have all contributed to the reduction of losses and insured higher efficiencies.

Capacities have been increased by the use of higher drafts and larger grate area, and when still higher ratings were desired, particularly with low-grade coal, the forced-draft chain grate was perfected. Different constructions have been employed in dividing this type of stoker into compartments, and there are variations in the amount of air space in the grate, air velocities and pressures, in the method of disposing of siftings, in the link used and in other details.

The forced-blast chain-grate stoker is adapted particularly for free-burning coals that require agitation of the fuel bed to break the crusting or caking action so often encountered with the slower-burning coking coals. It may be operated at continuous high overload capacities for days at a time with only slight variations in the steam output of the boiler. This operation is made possible by the uniform thickness of the fuel bed, the uniform blast pressures carried, and the uninterrupted disposal of ash and refuse from the grate. Such stokers may be operated efficiently under natural draft when burning as little as 10 lb. and as high as 35 lb. of coal per square foot of grate per hour. Forced-draft combustion ratings reach 55 to 60 lb. of coal per square foot of grate per hour.

This type of stoker is simple to operate and flexible in handling varying load conditions. It can be brought from banked fires to full load in time to meet any ordinary power-plant requirements. A cold boiler can be put on the line in 45 min. from the time of lighting fires. The boiler can be operating at 150 per cent of rating in 5 min. from the time it goes on the line, or it can be operating at 200 per cent of rating in 7 minutes.

FUELS USED AND RESULTS OBTAINED IN ELEVEN BOILER PLANTS EQUIPPED WITH CHAIN GRATES

Description of Station	Location	Name of Coal Used	Moisture, Per Cent	Ash, Per Cent	Volatile, Per Cent	Fixed Carbon, Per Cent	Sulphur, Per Cent	B.t.u. per Lb., Commercial Basis	Average Rating, Per Cent	Maximum Rating, Per Cent	Ranked Boiler Hours, Per Cent	Economizers	Efficiency of Steam-Generating Unit, Per Cent	Time Covered
Central station[1]	Middle West	Illinois	14.5	16	.....	.....	4	10,000	225	275	8	Yes	73.6	3 months
Central station	Middle West	Illinois	14.5	16	.....	.....	4	10,000	...	...	30	50%	69.4	3 months
Central station	Southwest	Kansas	4.66	11.7	33.05	50.62	4.2	10,561	...	...	...	No	69.4	24 months
Central station	West	Iowa	16.51	18.72	.....	.....	.....	8,891	180	...	32	No	73	12 months
Central station	Middle West	Indiana	9.8	17.7	33.3	49	4.2	10,000	170	230	30	No	70	12 months
Steel plant	Middle West	Indiana	18	12.2	35.2	52.6	2.20	10,150	140	...	...	No	71	12 months
Steel plant	Pittsburgh district	Pennsylvania	2.09	10.5	33.7	55.8	1.60	13,250	107	...	.	No	69.4	12 months
Central station	West	Colorado	23	12.5	32.5	32	0.20	8,865	...	...	...	Yes	72	1 month
Central station	West	Kansas	6	19	27	48	....	10,700	130	200	49	50%	69	1 month
Central station	Middle West	Ohio & Penn.	.....	.....	.....	.....	....	11,766	145	225	6	Yes	73.8	5 months
Central station[2]	Middle West	Illinois	14.5	16	.....	.....	4	10,000	271	...	20	Yes	78.7	1 month

[1] Part of the stokers in this plant are forced-draft units.
[2] All of the stokers in this plant are forced-draft units.

With the ordinary short-banked fire, which consists of a bed of coal 3 to 4 ft. in from the stoker gate, the remainder of the grate being bare, the boiler can be brought up to 200 per cent rating within 25 min., while with the long bank, in which 50 per cent of the grate is covered with fire, the boiler can be brought up to 200 per cent rating within 6 to 8 minutes.

Whether natural- or forced-draft chain grates should be installed depends upon conditions in the individual plant. The station load, banking periods, boiler absorption with or without economizers, and the limits of the draft available, are all involved.

Natural-draft stokers should be installed whenever the capacities demanded to meet the station load are within range of the natural draft available, whenever the load demand is steady or where peaks can be anticipated sufficiently far ahead to permit building up furnace conditions to meet them, and within the limits of these two conditions, whenever induced draft and economizers are used.

In the accompanying table are submitted some long-period operating figures from chain-grate power stations, taken from the operating records of large and reliable companies having engineering departments competent to compile them.

Overfeed Inclined Stokers

BY GEORGE I. BOUTON
Chief Engineer, Murphy Iron Works

Stokers of this type are of two general classes, the side-feed double-inclined, or V-type, and the front-feed, or single-inclined stokers. The early development of these stokers was along natural-draft lines. As steam plants have increased in size, and therefore boilers and stokers, this type has apparently reached a limit in a stoker having a projected grate area of 100 to 110 sq.ft. in a single unit, capable of burning sufficient coal, under forced draft, to generate about 60,000 lb. of steam an hour as a maximum.

The double-inclined side-feed stoker was the first to make its appearance in this country, Thomas Murphy fathering this particular line of development in a hand-operated stoker, beginning about 1875. The stoker had inclined grates, every second grate being movable, and was provided with a revolving toothed cylinder or clinker grinder, extending from front to rear along the bottom of the V, for the removal of clinker and ash.

In 1879 Murphy moved this device forward into a Dutch oven, for use in connection with a return-tubular boiler and added magazines and stoker boxes for feeding coal to the upper end of the grates. About 1880 he provided an engine drive, placing a reciprocating bar across the stoker shafts which moved the stoker boxes back and forth, the rocker bars which raised and lowered the movable grates, and a ratchet which rotated the clinker grinder. In all essential features this stoker is the stoker of this class of the present time, as represented by the Murphy, Detroit and Model stokers, although there are many minor changes in the stokers as built today.

About 1885 the front-feed inclined stoker was developed, the Roney and Brightman being bought out at that time. The Brightman apparently was not a financial success, and it gradually disappeared; a modified form of it, however, still remains in the Wetzel stoker. The Wilkinson stoker was bought out by Alfred Wilkinson and was in rather extensive use from 1895 to 1905, particularly for anthracite. It has now largely disappeared.

Originally, the grates in the side-feed stokers were set at an angle of 35 deg. with the horizontal. As the size of the stokers was increased, this angle was increased to 40 deg. and later to 45 deg., which is the present standard. Grates at this angle are suitable for bituminous and semi-bituminous coals. With non-coking coals a much flatter grate is desirable, and when coals of this sort are to be burned, it is advisable that the stokers be designed particularly for the coal in question. The grates in the Roney are at an angle of 35 deg. with the horizontal, and this stoker will burn anthracite and bituminous coal and lignite. The grates in the Wetzel stoker are also set at the same angle.

Where wood refuse or spent tanbark is used, this is usually burned in connection with bituminous coal, enough coal being burned to keep the grate surface covered. Spent tanbark will run about 60 per cent moisture, and when a half-and-half compounded mixture is used, about 85 per cent of the heat supplied to the boiler will be from the coal and the remainder from the tanbark.

The side-feed double-inclined stoker may have either a flush-front setting, which is limited to the smaller return-tubular boilers and horizontally baffled water-tube boilers, or a Dutch-oven setting for the larger return-tubular boilers, vertically baffled horizontal water-tube boilers, and boilers of other types. These stokers are made in various sizes both as to width and depth, varying from a stoker with a grate surface 4 ft. wide and 3 ft. deep to one having a grate 12 ft. wide and 9 ft. deep. In the larger stokers 1 sq.ft. of projected grate area is provided for each 62.5 sq.ft. of heating surface in the boiler, and in the smaller ones 1 sq.ft. for about each 50 sq.ft.

Stokers of this class are usually driven by a small steam engine operating the reciprocating bar through a chain of gearing, the details of the gear reduction being arranged to suit the particular stoker. An engine is preferable to a motor, as the exhaust steam which it supplies is useful for chilling clinker so that it can be handled readily.

In this stoker the fuel bed is about 8 to 10 in. thick at the upper end of the grates, thinning down gradually toward the clinker grinder. Where proper draft is provided, stokers of this class will take care of various loads up to 200 or 225 per cent of boiler rating, although the draft available usually limits the capacity to 200 per cent of boiler rating or less. Where there is a shortage of draft, it is possible to compensate for this in part by increasing the amount of "rousting," or hand manipulation of the fuel bed. At 200 per cent of boiler rating the draft loss through the fuel bed will vary from 0.3 to 0.5 in. water gage, depending on the kind of coal and the amount of rousting.

Where it is desired to obtain more capacity than can be obtained with the natural draft available, it is sometimes possible to do this by adding forced draft. The limit of capacity under forced-draft conditions will be that point where the draft over the fire is so reduced that fire is blown out of various openings. This will be when the draft over the fire is reduced below 0.10 in., probably to about 0.05 in.

With forced draft properly installed and skillful firing, it is possible under favorable conditions to get in the neighborhood of 300 per cent of boiler rating. The fires are rather thin for forced-draft work, and it requires closer attention to the fuel bed to keep the grates

covered than in the case of stokers using thicker fuel beds.

Of the many forms of front-overfeed inclined stokers that have appeared, the Roney and Wetzel are still being built. The Roney is a natural-draft stoker only. Its construction is well known.

In operation the best practice is to control the rating on the boiler as desired by means of the boiler damper and not by thickening or thinning the fuel bed. There are installations in service where there is automatic regulation controlled by steam pressure, but as a rule it has been found that hand regulation of the boiler damper is about the most reliable and effective method for this class of stoker. It is suitable for burning anthracite and bituminous coals and lignite.

The Wetzel stoker is somewhat similar to the Roney, the principal difference being in the form of grate used. Instead of being made up of bars extending across the furnace and rocking, the grate is made up of a series of bars extending from front to rear. These bars are ribbed to prevent sifting, the upper end of the grate is supported on a short rocker arm so that it has a slight forward-and-backward motion, and the lower end on an arm placed at a somewhat different angle, so that the motion of the lower end of the grate is practically at right angles to the grate surface.

Design and Operation of Underfeed Stokers

H. F. Lawrence, mechanical engineer of the American Engineering Co., presented an interesting paper on underfeed stokers, tracing their early development and describing briefly the distinctive features of the various makes of single- and multiple-retort stokers. The principles of operation of the underfeed stoker were given, with a summary of the results obtained in practice. This stoker is particularly adapted for burning bituminous and semi-bituminous coals and with slight modifications has burned successfully lignites and coke braize. It is quick to respond to load demands and in a few minutes can be brought up from normal to maximum rating.

Automatic regulation was receiving much attention, but it was the author's opinion that regulating apparatus never would be developed to the point where adjustments would not be required from time to time. An ideal regulating equipment, in addition to controlling the fuel, air supply and drafts, also should control the feed water in proportion to the load. Practically all systems in use are controlled by variations in the steam pressure, and as the damper regulator is sensitive to slight changes in steam pressure, hunting will take place unless its action is retarded to prevent the resulting wide variations in air pressure. Much better fuel economy is obtained by damping the regulator so that a greater variation in steam pressure is required to operate it through its complete stroke.

Of the various types of fans used in stoker service, the high-speed fan with narrow forward-curved blades had a wide range of volume delivered with only slight variations in the static pressure, but it was not well adapted for use on underfeed stokers, because it will not operate in parallel with other fans and it has a rapidly increasing horsepower requirement as the static pressure drops and the volume increases. The radial-tip fan, also narrow bladed and of high speed, has similar characteristics. The partial-backward-curved high-speed fan and the low-speed steel-plate fan give better service, due to a steeper pressure curve, but the full-backward-curved fan with long blades and high speed has the best characteristics for stoker service. It has a steep static-pressure curve, a comparatively flat horsepower curve and the additional characteristic that after reaching the maximum horsepower any further increase in volume due to the reduction of static pressure, will reduce the horsepower required.

Clinker adhesion to the side walls of a furnace, one of the most serious operating difficulties encountered, had been obviated to a great extent by the use of perforated firebrick blocks along the clinker line through which air is blown from the stoker air duct, by high-side tuyeres, by cast-iron side-wall air boxes or in some cases by the use of carborundum brick.

Minimum setting heights for various types of boiler, as adopted by the Stoker Manufacturers' Association in conjunction with the American Boiler Manufacturers' Association, were tabulated by the author. In an early issue a more complete abstract of this paper will be published.

Chronological History of Stoker Development

In a paper on this subject, A. H. Blackburn, chief engineer for the Under-Feed Stoker Company of America, traced the developments in stokers from the first Jukes patent in 1838 up to the present day. The author covered underfeed single- and multiple-retort stokers, underfeed lateral-retort stokers, overfeed inclined-grate stokers and traveling- and chain-grate stokers. The paper was printed in full in the Dec. 5 issue of *Power*.

Stoker Discussion

Upon invitation of Chairman Breckenridge, the extemporaneous discussion was opened by W. R. Roney, inventor of the Roney stoker, who reviewed the development of the mechanical stoker and expressed the opinion that the human element is the important factor in the satisfactory operation of any stoker.

This latter point was emphasized by other speakers, including D. M. Myers, who stated that the final result might be expressed as the product of mechanical efficiency and the human efficiency. He inquired as to what stoker manufacturers thought of automatic regulation and as to what is being done in adapting mechanical stokers to marine use.

Commenting on the paper by Mr. Lawrence, he regretted the omission of the relation between the type of setting and boiler rating and called attention to the fact that the tables in Mr. Marsh's paper omitted mention of burning fine sizes of anthracite.

Walter Polakov called attention to the fact that a stoker is automatic only in so far as it substitutes mechanical power for manual power, but there is danger in assuming that the automatic controllers will replace proper supervision. These automatic control devices often introduce a lag which, if not properly supervised, will result in lost efficiency. He preferred hand regulation especially for oil fires.

J. E. Woodwell believed that many of the difficulties

met with in stoker operation are attributable, in a large measure, to the coal situation. He advocated the practice of excess stoker capacity in order to save brickwork and thus keep boilers in service for longer periods.

Commenting upon automatic regulation, he pointed out that the ideal system would be one that would provide co-ordination between the draft above and below the fuel bed and the rate of coal fed. He believed automatic control under proper supervision to be far superior to manual control.

Theodore Main related troubles experienced with chain grates due to the various sizes of coal, one of the causes being that different coals demand different amounts of excess air. If the coal is not uniform, there will be coarse coals on the sides accompanied by too much excess air and the fine coal will pack near the wall. This condition is partly remedied by sectionalizing the grate so as to maintain a more even fuel bed. He also advocated sealing the end of the fuel bed either by a water-back or with ashes. Another difficulty experienced with forced draft and chain grate was the dirt coming out in front of the furnace. He strongly urged that the operator be given adequate instruments in order to know what he was doing.

Difficulties of Marine Application

Edwin Lundgren, in answering Mr. Meyer's question on marine practice, gave the following reasons for the little progress that has been made:

1. Steamers as a rule have to take on coal at ports in different parts of the world, hence receive various kinds of coal, and it would be difficult to employ a stoker adapted to these various grades.
2. A low space between the boiler and the bottom of the ship makes it very difficult to install a stoker and dispose of ash and clinker.
3. In spite of this some progress has been made and there are several ships in service equipped with mechanical stokers.

A further explanation to the marine situation was given by J. J. Nelis, who pointed out the distinct problems encountered in marine work. In the first place there is not control over the marine operator as to repairs, etc., that have to be made at sea; secondly, there are the limitations in space as previously referred to by Mr. Lundgren. However, in the speaker's opinion the boiler problem at sea is not so much one of supplying the fuel as that of troubles due to condenser leakage. Stokers have been tried under Scotch boilers, but it is difficult to dispose of the clinkers. One advantage that the marine practice has over the stationary is the steady load conditions. The marine Diesel engine as a strong competitor may stimulate further activity in the marine field.

The next speaker, Albert Cary, expressed the opinion that the common rating of pounds of coal burned per square foot of grate surface per hour did not mean much, especially with chain grates and highly volatile coals, inasmuch as the volatile is burned in the furnace and what is burned on the chain grate is mostly carbon.

C. G. Spencer was of the opinion that practically each kind of fuel must have a stoker adapted to it; also that the furnace design should be especially adapted to the fuel to be burned. As a result of the recent coal strikes the big problem at the present time in the East is the necessity of burning various grades of fuel.

Commenting upon troubles due to varying sizes of coal, H. C. Heaton, of Chicago, was of the opinion that these troubles are in many instances caused by poor crushing and the adhering of coal to the sides of the furnace. The swinging spout he believed to be the best means of distributing the coal to the stoker hoppers.

At this point the chairman, Professor Breckenridge, diverted the discussion to the question of smoke abatement and remarked that the fuel committee of the A.S.M.E. is now working in collaboration with committees of other organizations upon the drawing up of a tentative specification for a smoke ordinance. In this connection, O. P. Hood, mechanical engineer of the Bureau of Mines, called attention to the chaotic situation regarding smoke in different cities. "Local control," he said, "is very apt to be political." Therefore, the committee is working along the lines of drawing up a simple fundamental ordinance with the idea of leaving the details of administration to suit the requirements of the different localities.

Speaking from the operator's point of view, H. M. Burke was of the opinion that in a large plant it is not possible to provide automatic control for the whole plant. At the same time he believed manual control for the whole plant to be inadvisable. The preferable system is to carry the base load with automatic control and have manual control on such boilers as are needed to carry the peak load fluctuations, inasmuch as manual control can take care of these changes to better advantage. One of the dangers of employing automatic control exclusively is that the firemen are prone to rely wholly upon it.

This practice of part mechanical and part manual control was also advocated by J. B. Crane, of the Ladd Boiler Co.

Maxwell Alpern, on behalf of the Stoker Manufacturers' Association, commended the authors of the papers presented. He stated that valuable information was now obtainable as to the proper combustion space for different types of installations and also on the quality of refractories and added that the association was cooperating with the manufacturers of refractories toward obtaining a better product.

Sanford Riley referred briefly to the principal features of the underfeed stoker and, replying to the question asked by Mr. Myers regarding the fusion of coal on this type, explained the process of removing the ash from the fuel bed.

Mr. Marsh expressed appreciation to those who had taken part in the discussion and called attention to the fact that the important thing in boiler operation was the cheap making of steam (the cost per 1,000 lb. of steam) and not efficiency. He looked for early elimination of a number of the problems at present met with in stoker operation and said it was now possible with chain-grate stokers to get the combustible in the ash down to 10 per cent with 40 per cent excess air.

W. J. Wohlenberg, in referring to automatic control, pointed out the need of similar characteristics in the different valves and speed controllers in order to obtain good results when operating a number of boilers in parallel, particularly with independent fan and stoker drive. A number of speakers in discussing this subject expressed the opinion that the real need for efficient operation is the necessary instrument and controls accessibly located and centralized, and under the supervision of an intelligent operator.

Power Section Papers

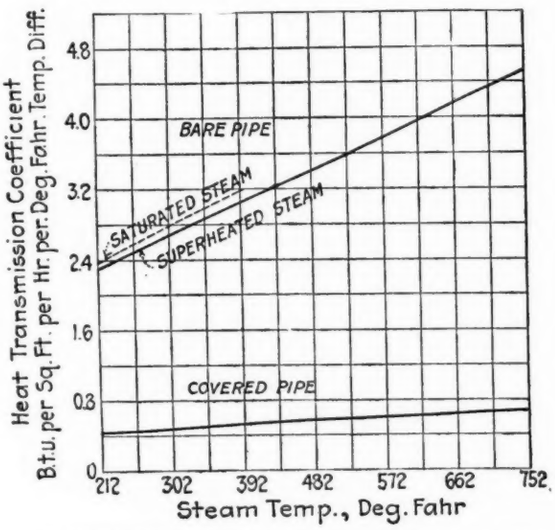
UNDER the chairmanship of John Lawrence the Power Session on Thursday afternoon was notable for the keen interest displayed by the many prominent engineers who discussed the papers. The keynote of the session was power-plant efficiency with particular reference to high steam pressures and temperatures. Papers by George Orrok and Linn Helander treated future possibilities in a broad way, while the best modern practice was exemplified by a report of elaborate boiler tests made at Connors' Creek. As subjects directly associated with high steam temperatures, two other papers were presented dealing, respectively, with pipe bends and the action of superheated steam in pipes.

High Temperature and High Pressure Steam Lines

BY B. N. BROIDO
Consulting Engineer, Superheater Company

In spite of the importance of the subject very little has been published in this country upon the pressure drop, radiation losses and proper steam velocities in pipes conveying superheated steam. Since practically no experiments along this line have been made here, the author draws most of his data from foreign experimenters, chiefly those in Germany.

With saturated steam the temperature of the inner pipe wall is practically equal to that of the steam at all velocities, so that satisfactory tests for radiation losses may be conducted by connecting one end of the line to



TRANSMISSION COEFFICIENT *K* OF BARE AND COVERED PIPE

K is expressed in B.t.u. per square foot per hour per deg. *F.* temperature difference between the steam and the outer air. The insulated pipe is covered with 2 in. of diatomaceous earth.

the boiler and closing the other end so that the only flow is that required to replace the condensed steam. The condensation is then easily collected and measured.

Radiation tests with superheated steam are much more difficult since there is a considerable difference in temperature between the steam and the wall, this difference depending upon the velocity, pipe size, etc. Such tests must be so conducted that the steam leaving the test section of pipe is still superheated.

The figure gives a comparison for saturated and superheated steam, of the coefficients of heat transfer per degree difference in temperature between the steam and the outer air. As might be expected, the coefficient for bare pipe is appreciably less with superheated steam than with saturated. With covered pipe there is practically no difference, because the covering so reduces the flow of heat out of the pipe that the temperature even of the superheated steam is but little less than that of the inner wall of the pipe. The tests represented by these curves were made with 3-in. pipes, but practically the same curves were obtained with 6-in. pipes.

Although, for the same steam temperatures and with well-insulated pipe, the actual heat losses through the pipe wall are practically the same for saturated and superheated steam, the condensation accompanying radiation from pipes carrying saturated steam entails the additional loss of part of the heat of the liquid, unless the drips are returned to the boiler. Again, superheated steam permits the use of considerably smaller pipes with a corresponding reduction in heat loss, as well as a reduced investment in piping and covering. This is the case because considerably higher velocities are practicable with superheated steam, partly due to the reduced friction in dry pipes and fittings, and partly due to the fact that moisture, which is a common cause of vibration and water hammer at high velocities, is eliminated. On the other hand, for the same pressure, the superheated steam obviously has a higher temperature, which tends to increase the heat loss.

All things considered, a system conveying moderately superheated steam should have a smaller heat loss expressed as a percentage of the total heat in the steam conducted, assuming that the pipes used are of suitable size for saturated and superheated steam respectively, and that the degree of superheat employed is not high. This does not mean that high superheats are not advantageous. The advantages of high superheat in turbines, for example, far outbalance any slight increase in the radiation losses from the pipe lines. The usual velocities with saturated steam in commercial pipes range from 3,000 to 6,000 ft. per min. With superheated steam at high temperatures velocities of 12,000 to 15,000 ft. per min. for the larger pipes are giving satisfactory results.

This paper was presented by title only and will be read at the Jan. 4, 1923, meeting of the Metropolitan section of the A.S.M.E. The discussion was deferred until that time.

Commercial Economy of High Pressures and Temperatures

BY GEORGE A. ORROK

[While Mr. Orrok's paper was printed and editorially discussed in the Oct. 31 issue of *Power*, it is considered sufficiently important to warrant a repetition of the main conclusions in the following outline.—*Editor.*]

The over-all efficiency of steam-power plants will undoubtedly continue to increase. This may be brought about by increasing the theoretically available energy,

or the percentage of that energy which is actually obtained. The former may be accomplished in three ways: (1) By increasing the temperature, (2) by increasing the pressure, and (3) by changing the cycle.

So far as can be seen at the present, 1,100 deg. F. appears to be the upper limit of temperature with any materials that are now obtainable. It will be noted that this temperature is only a few hundred degrees beyond what has already been attained in the newer plants. On the other hand, a preliminary survey shows no insurmountable obstacles to pressures of 1,200 to 1,500 lb. Curves plotted, comparing the Rankine cycle and the regenerative cycle, show a distinct thermal advantage for the latter at all temperatures and pressures. This advantage increases only slightly with increase of temperatures at constant pressure, but considerably with increase of pressure at constant temperature.

After allowing for the estimated increase in investment charges, preliminary calculations seem to show that so long as the Rankine cycle is used, there can be little, if any, economic gain by increasing either pressure or temperature beyond present commercial limits. This conclusion is, of course, subject to modification in cases of changes in the relative cost of fuel and equipment.

The regenerative cycle, on the other hand, seems to show a distinct economic advantage over the Rankine, even at 700 deg. This advantage increases with increased pressure and is still increasing rapidly at 1,200 lb. There seems to be a slight additional net gain at all pressures by using 1,000 deg. temperature instead of 700, but the difference is not great on paper and might easily prove to be non-existent in practice.

The conclusion is drawn that, so long as we stick to the present cycle, our chief hope of increased economy must lie in perfecting details and obtaining a larger percentage of the theoretically available heat. On the other hand, it seems quite possible that there may be an economic future for pressures as high as 1,200 lb. in plants operating on the regenerative cycle.

Discussion

As was to be expected from the general interest in the subject and the startling conclusions presented, a most interesting discussion developed in which many prominent engineers took part. These men, being specialists in the various branches, including power-plant operation, turbines, boilers, piping, valves, power-plant design, etc., were able to express opinions based, in the main, upon long study and experience.

Among those taking part in this discussion were John A. Stevens, I. E. Moultrop, P. Junkersfeld, A. M. Houser, C. H. Smoot, Prof. W. J. Wohlenberg, Dr. D. S. Jacobus, V. T. Malcolm, Henry D. Hibbard, Robert Cramer, Max Toltz, Francis Hodgkinson, N. E. Funk, C. M. Hardin and O. F. Junggren.

Mr. Stevens presented diagrams for determining the increase in first cost warranted for any given increase of efficiency with a given price of coal and given load factor.

Mr. Moultrop was somewhat skeptical about the practical application of very high pressures. He agreed that boilers and turbines could be built to meet such conditions, but expected trouble with steam lines and particularly with flanges and valves. These, he said, were the key to the situation. As to temperatures, he thought the present practical limit should be placed at about 700 deg. F. Moreover, there was some doubt about the efficiencies obtainable at high pressures, since the steam tables were not reliable above ordinary commercial pressures. Mr. Moultrop's whole discussion leaned strongly away from theoretical considerations and emphasized the viewpoint of the operating man. In his opinion the question of a small thermal saving was not nearly so important as low first cost, simplicity and absolute reliability.

A suggestion made by another speaker was that the curves given in the paper be refigured for various prices of coal, load factors, etc. The most important factor was the generator-output factor. This was far less than generally imagined and dropped off rapidly after a few years of service.

In view of the fact that most of the discussions centered about the practical difficulties of operation, Professor Wohlenberg's critical study of the paper, from the thermal standpoint, was of particular interest. His criticism may be boiled down as follows:

1. It is not reasonable to figure gain on the basis that present plants operate on the Rankine cycle, since most of them really operate on a one-stage regenerative cycle.

2. Boiler efficiency drops off at high pressure on account of higher water temperatures and consequent higher flue temperatures. This could be remedied only by using air heaters, since economizers would prevent the use of the complete regenerative cycle as planned. The commercial standing of air heaters is still in doubt.

3. The turbine efficiency ratio would also drop off, because the high-pressure section of a turbine is the least efficient and also because less superheat could be used with high pressures.

Professor Wohlenberg then exhibited a new table corresponding to Mr. Orrok's, but with figures modified to accord with the considerations just given. The overall efficiencies thus obtained were considerably lower than those given by Mr. Orrok. For example, where Mr. Orrok showed a saving of 30.8 per cent of the fuel by changing from ordinary heat-balance operation at 200 lb. to the regenerative cycle at 1,200 lb., Professor Wohlenberg's figures showed a saving of only 19.1 per cent. This cut the saving per kilowatt-hour practically in half, and made the fixed charges greater than the gain. On the other hand, Professor Wohlenberg expressed the opinion that the future would see an increase in fuel cost and a reduction in the cost of high-pressure equipment which might throw the balance in favor of high pressures.

Dr. Jacobus said that boilers could certainly be built for 1,200 to 1,500 lb. pressure, but that trouble might be expected with flanges.

The rest of the discussion resolved itself mainly into the arguments pro and con on the possibility of making flanges and fittings to work satisfactorily at high pressures and temperatures. Some held that proper materials and designs would permit the highest pressures suggested to be handled at moderately high temperatures. V. T. Malcolm, for example, told of a valve that gave entire satisfaction at 600 lb. pressure and 900 deg. temperature. He said it was all a matter of proper design, materials and construction. Others held that serious trouble would be met at much lower temperatures and pressures.

In his closure Mr. Orrok referred chiefly to the fact that different steam tables gave slightly different results. The remainder of his closure was to be submitted later in writing.

Feed Heating for High Thermal Efficiency*

By Linn Helander

This paper considers, first, for a theoretically perfect plant and secondly for an actual plant of 25,000 kw., the effect of feed temperature upon plant efficiency, the object being to determine the best feed temperature from the thermal point of view. No account is taken of investment or operating costs.

Various methods of feed-water heating are considered, including single-stage heating by house-turbine exhaust and single- or multiple-stage heating by steam bled from the main unit.

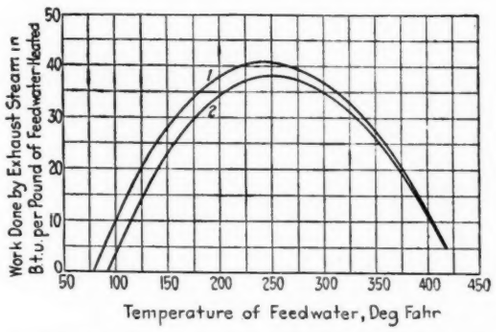


FIG. 1—RELATION OF FEED TEMPERATURE TO WORK DONE BY HEATING STEAM IN THEORETICAL PLANT

Considering first a theoretically perfect plant with single-stage heating by the exhaust of a house turbine, it develops that the best plant thermal efficiency comes with a feed-water temperature such that the power obtained from the house turbine is a maximum. This power is the product of the power generated per pound of steam supplied the house turbine by the number of pounds so used. The two limiting feed temperatures, that of the main condensate and that in the boiler, give zero power because, in the first case no heating steam is used, and in the second no expansion or pressure drop is possible.

The maximum house turbine power must come at an intermediate point about halfway between these two temperatures, as shown by the curves in Fig. 1. These give the theoretical work obtained from the heating steam with various feed temperatures and with the initial steam at 325 lb. gage pressure and 200 deg. superheat. Curve 1 is for a 29-in. vacuum (main condensate at 79 deg. F.), while curve 2 is for a 28½-in. vacuum (92-deg. condensate). The first case shows the best feed-water temperature around 240 deg., and the second around 260 deg.

A similar curve drawn for two-stage heating (as by two bleeder heaters) with equal heating per stage, shows a best feed-water temperature of 300 deg. for the 29-in. vacuum. The more stages used the higher is this best feed-water temperature. With an infinite number of stages it becomes that of the boiler, and the plant efficiency equals that of the Carnot cycle. It must be remembered that this applies to a theoretically perfect plant. An actual plant gives the best thermal economy at somewhat lower temperatures.

Fig. 2 gives the predicted actual plant heat consumption per kilowatt-hour for a 25,000-kw. plant under various conditions. Curve 1 is for a plant without economizers, using a 1,600-kw. house turbine and not bleeding the main unit, while curve 2 is for a plant without economizers, using a 650-kw. house turbine and supplementing its exhaust with steam bled from the main unit. Curve 3 is the same as curve 2, except that an economizer is used, while curve 4 is the same as curve 3, but with twice the amount of economizer surface. Curves 5 and 6 show the loads developed by the heating steam, the first being for the 650-kw. house turbine with bleeding, while the latter is for the 1,600-kw. house turbine without bleeding.

Discussion

Practically the only adverse criticism made by those who took part in this discussion was that the author had perhaps paid too much attention to the house turbine, the general opinion being that the house turbine as an important factor in power-plant economy would soon be generally replaced by bleeding of the main units. Otherwise the discussion consisted almost entirely of additional data corresponding fairly well with those given by the author.

An example was submitted from a study made to determine the proper locations for bleeder taps in a plant using boilers without economizers. The conclusion for the given case was that steam should be bled from the turbine at the tenth stage for single bleeding and at the ninth and fourteenth for double bleeding.

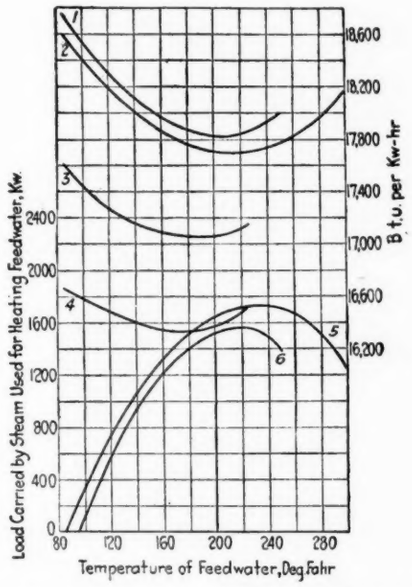


FIG. 2—EFFECT OF FEED TEMPERATURE UPON PLANT EFFICIENCY AND LOAD CARRIED BY HEATING STEAM FOR ACTUAL 25,000-KW. PLANT

One of the points brought out was that if, as indicated, the best feed temperature was often over 200 deg. even with an economizer, operators might look for relief from difficulties such as sweating, caused by low feed temperatures. In view of the cost and complication of bleeder heaters and the decreasing gain for each succeeding heater, it seemed unlikely that more than three bleeder heaters could be profitably used.

A case was cited in which a study had been made, in connection with the design of a large central station now under construction, to determine the best exhaust

*A more complete abstract of this important paper will appear in an early issue.

pressure for the house turbine. This indicated that with no bleeding the best exhaust pressure was atmospheric provided the load on the house turbine could be changed at will.

The same speaker pointed out that recirculation of generator cooling air was justified, not by the small heat recovery thus made possible, but by considerations of cleanliness and safety.

W. M. Keenan, in discussing the question of the best points for the bleeder connections, said that the new plant of the Brooklyn Edison company now under construction will bleed at two points approximating 12 lb. and 100 lb. absolute. Preliminary studies for single-stage bleeding showed that the best pressure for that case lay between twenty and thirty pounds absolute.

Among those commenting on the probable discarding of the house turbine was Prof. A. G. Christie, who used the Willan's Line to illustrate the fact that the house turbine was not the best method of heating feed water.

The generation and use of steam at very high pressures was an old idea, according to F. Hodgkinson, who described some experiments made early in the last century. He said the only excuse for the house turbine was reliability of auxiliary power and pointed out that this could be obtained in other ways. If a house turbine were to be maintained in operation at no load as an emergency stand-by, its windage losses could be greatly reduced by allowing it to exhaust directly to the main condenser. He stated that practically all large turbines were now designed to permit of bleeding. A common plan was to allow four connections, as follows, in terms of temperature or pressure: 140 deg. F., 200 deg. F., 50 lb. absolute and 120 lb. absolute.

As an argument against stage heating one of the engineers discussing the paper mentioned the extra complication which might be serious in time of emergency. There was danger, he intimated, of making the power plant so complicated that the operating force would have to be made up of consulting engineers.

Replying to criticism of the use of the house turbine in his computations, Mr. Helander said the formulas given could easily be applied to plants using stage heating without a house turbine. He reserved his other comments for a written closure to be submitted later.

The Elasticity of Pipe Bends

By Sabin Crocker* and Sterling S. Sanford

The use of expansion loops, offsets in the line, right-angled turns and similar devices, to furnish flexibility for expansion and contraction in pipe lines resulting from temperature changes, has been general practice for years. Such bends, which utilize the elasticity of the pipe itself, are used commonly for high-pressure work in preference to slip joints, corrugated expansion joints or swivel offsets in which screwed elbows are arranged to turn on pipe threads. The use of pipe bends reduces internal friction in the piping by providing easy turns, eliminates unnecessary fittings and joints, and facilitates clearing other pipes and structural interferences.

Up to the present time the disposal of expansion and contraction in power-plant piping has been largely a matter of judgment rather than of rational calculation on the part of the designer. This has been due to a general lack of knowledge or interest regarding the principles and methods involved in calculating the forces and stresses resulting from the expansion of piping. However, if certain rather fundamental principles of engineering mechanics are brought into play, it is usually possible to determine numerical values with fair accuracy during the progress of design, and make use of this knowledge to improve the piping layout. As the drift toward higher steam pressures and temperatures in turbine practice continues, the problem becomes more and more important. Since there is also a tendency for the steam turbine to grow smaller relatively to the size of the steam line to which it is connected, there is a danger that excessive stresses will be set up in the turbine casing as a result of expansion in the pipe line, unless the piping designer knows how to calculate the forces involved. This paper is presented to set forth a method of attacking the problem. It also shows wherein the authors' methods and test results differ from the work of previous contributors to the subject and the extent to which they check earlier work.

The amount of expansion to be cared for in a pipe line can be accurately computed, provided the temperature range between extreme hot and cold conditions, the length of pipe, and the coefficient of expansion for the material are known. Having computed the amount of expansion, or elongation of the pipe, the problem resolves itself into determining whether the piping arrangement under consideration has sufficient "spring" to absorb this elongation without producing either undue fiber stress in the material or excessive forces tending to tear the piping loose from its anchors. At the same time the proportions of the line must be economical and be adjusted to clear any structural interferences in the plant. Wall thickness and diameter of pipe, radius of curvature, and general layout all affect the flexibility that can be obtained with a given run of pipe.

The inadequacy of the usual methods of steam-pipe design has been brought forcibly to the attention of the Detroit Edison Co. by several minor mishaps during the last few years. Fortunately, none of these was of a serious nature, but they did serve to show that piping laid out according to the best modern practice may be subject to forces of unexpected proportions. Thus in one instance unexpectedly large reactions caused a 14-in. high-pressure steam main to tear loose from what was supposed to be an adequate anchorage. This incident, and others of a somewhat similar nature, led those responsible for design and operation to ask themselves whether such failures could not be avoided by more intelligent design. Consequently, in undertaking the design of the company's Marysville power plant, where the elongation per 100 ft. of steam pipe amounts to almost 7 in. and the steam pressure is 300 lb. per sq.in., it was decided that pipe expansion must be cared for in a rational manner if such a thing were possible. Accordingly, the investigation here reported was undertaken to determine the fundamental relations between deflection, force resisting deflection, and stress set up in expansion pipe bends of various shapes. These relations were first determined mathematically, and later checked by physically testing bends of shapes which readily lent themselves to measurement of the quantities involved. The results thus obtained were then applied to the more complicated conditions in actual pipe lines. As a result, it was possible to design the piping layout for the first section of the Marysville power plant, which has just been put in operation, so

*Piping engineer, The Detroit Edison Company.

that the following results are obtained without allowance for cold springing: Maximum fiber stress in pipe wall, 6,900 lb. per sq.in.; maximum thrust against pipe anchorage, 680 lb.; maximum thrust against turbine flange, 580 lb. If credit is taken for cold springing, the maximum stress and forces given are further reduced. These values have been obtained without making the expansion bends unnecessarily large.

To summarize, the paper treats expansion bends in pipe lines as if they were beams acted on by the forces set up by expansion of the piping. Upon this basis formulas have been derived for the forces and stresses in some of the more common types of bends. In order to check the formulas, several bends were tested by applying a force to one end of the bend and then measuring the force and the deflection. In some cases the results substantiated those given by the formulas, and in others the bends were more flexible than the formulas indicated. For an explanation of this, the authors refer to Professor Bantlin's experiments, which tend to show that this extra flexibility present in some cases is due to waves or folds formed in the pipe wall when the bend is made. The formulas are presented graphically in three charts for use in selecting the proper shape and size of bend to take up a given expansion. In the light of the material presented in this paper the limits of safe expansion values for pipe bends commonly quoted in engineering texts and handbooks, are apparently correct only for the double-offset expansion U-bend. For the other shapes the published values are much in excess of those given here. It is the author's contention that these limits should be revised to agree with the formulas presented in this paper, for unless the published tables are used with large factors of safety, the forces and stresses existing in pipe lines will be excessive and dangerous.

Discussion

Robert Cramer was gratified to see that the authors made the attempt to compare theoretical and experimental results. As a possibility of error he pointed out that contrary to the assumption in the paper, the neutral fiber in a bend did not go through the center of gravity of the cross-section of the metal as it did in a straight beam. There was considerable error in this assumption, and this was more pronounced in the shorter bends.

As the experimental and calculated results checked in certain cases and were so far off in others, it was his suggestion that the authors look for some mistake in the investigation.

In this work the deflecting force always was supposed to be at right angles to the cross-section at the point of application. After laying down a pipe line cold and then admitting steam, it was important to see how much the pipe had moved and what force was necessary to bring it back to the original position. To bring it back exactly a twisting effort must be applied.

Francis Hodgkinson did not see the need of so many fancy bends in pipe lines. Generally, sufficient flexibility could be secured by using straight lines at right angles to each other. Also to give flexibility to take care of torsional deflection of pipe lines, some length of line was necessary.

In commenting upon some of the installations made by his firm, Thomas E. Murray, Inc., Jay Freiday referred to trouble with expansion loops in pipe bends that had not been properly annealed. A growth of 2 in. in a few months had been noticed in a 14-in. line with 90-deg. bends. They never had experienced excessive pressure drops in expansion loops made up of straight pipe and U-bends.

Mr. Whitney referred to the statement in the paper crediting the extra flexibility secured in some cases to the waves or buckling formed in the pipe wall when the bend is made. He pointed out that as the fibers were stressed more on the outside, the buckling, instead of hurting the bend, made it better. The waves did not retard the flow of steam, but tended to take up expansion in both directions. In commercial piping the fiber stress should not exceed 5,500 to 6,000 lb. per sq.in. The thicker the pipe used the less the stress on the inside and the more on the outside, so that an external fracture may develop. For this reason seamless tubing, particularly for pipe bends, was to be preferred.

John A. Stevens in certain installations had used standard lengths of pipe and in each case where the flange failed, had to increase the length of the bend. It was his belief that all steam lines should not have bends of more than 45 deg., not from the standpoint of expansion, but to keep down erosion and cutting of the piping. He recommended the use of combination separators and reservoirs to keep water and foreign material from getting into the turbine.

George A. Orrok made some pertinent inquiries. It was his understanding that the work had been done on cold piping with no steam pressures within. For an analogy he referred to an automobile tire flat and inflated, and the difference in its behavior. Similarly, he wondered if 200 or 300 lb. pressure within a pipe bend would make any difference in the results obtained, and again what would happen to the bend when the temperature was around 700 deg. F. and the elastic limit was on the decline? Would there be enough deformation to reduce the thrust?

In closing the discussion, Mr. Crocker stated that repeated tests had not served to diminish the difference found between calculated and experimental results. In the plant it was their practice to cold spring the pipe to take up about one-half of the expansion they expected to get. This served to relieve the stresses in low-temperature lines, but was of no value in high-temperature lines carrying superheated steam where the pipe took a permanent set. Temperatures had no effect on the forces or thrust when the elastic limit was not exceeded. To get the total thrust, it was necessary to take into consideration the steam pressure.

Tests of Type W Stirling Boiler At Connors Creek

Since the original installation of the large type W Stirling boilers by the Detroit Edison Co. in 1911 and the tests conducted at that time by Dr. D. S. Jacobus, operating experience has brought about many improvements, both in methods and in design of auxiliary equipment, yet it was felt that there still remained further opportunities for improving the operating performance. With this end in view eight series comprising fifty constant-rating tests were made during which four different grades of coal were burned and four different arrangements of the boiler baffling tried out. In addition several tests were made to obtain data on different methods of banking, the effect on the tempera-

ture of the flue gases of varying the time interval between the blowing of flues, and different methods of operating boilers during the low-load period at night. An outline of these tests extending over a period of nearly five months, the conditions existing, the results obtained and a thorough analysis were incorporated in a comprehensive paper by Paul W. Thompson, of the Detroit Edison Company.

Some idea of the magnitude of the undertaking may be gained from the fact that the total coal weighed to the stokers during the entire test was 12,137 tons, and the total water fed to the boilers 101,200 tons. During the highest rating test the coal consumption averaged 22,550 lb. an hour. A complete record was maintained of the weights of coal and water during periods between tests, including seven firing-up and burning-out periods from which data on over-all efficiency for the entire period up to and including test No. 76 was computed and found to be 77.9 per cent.

As a result of the tests on different baffle arrangements, seventeen of these large boilers have been rebaffled with an improvement in boiler-plant efficiency and an increase in the degree of superheat of the steam. An aftermath of the test was the development of a new design of this type of boiler by the Babcock & Wilcox Co., and the installation of four of these boilers in the new Marysville plant of the Detroit Edison Co. More complete details of the tests will be presented in an early issue.

Discussion

In discussing the paper, Dr. D. S. Jacobus stated that complete tests of this kind spelled progress. Although the cost of conducting them had been considerable, the expense would be paid many times over by the savings in coal consumption. The tests showed clearly that the change in baffling had improved the economy and raised the superheat. And better still, the results had been put into practice on the other boilers. He had been impressed with the degree of accuracy attained. The author and others at the plant were to be congratulated for this excellent piece of work. It would prove of benefit not only to the company responsible. but to the engineering fraternity at large.

Prof. L. P. Breckenridge had been impressed with the development in the art of boiler testing. The present effort was a fitting climax and an excellent sample of the kind of work that should be presented to the Society. B. F. Groat laid emphasis upon the great amount of detail involved when studying the performance of any machine and the need of publishing the data in full. He desired to see the tables that had not been incorporated in the printed paper. D. B. Rushmore, in deploring the confusion resulting from expressing temperatures in both Centigrade and Fahrenheit, expressed the hope that the time would come when one thermometer would be standard.

Steam Tables

At the steam tables session Tuesday afternoon satisfactory progress was reported in the researches on which the new data will be based. George A. Orrok spoke of the reception this work has met with in Europe. Approval had been shown by the French engineers and in all probability they would adopt the results obtained. The interest of the British engineers also had been aroused to the point that Collendar was revamping the equipment he formerly used and would be in a position to help check results. Mr. Orrok was highly optimistic, and it was his conviction that a steam table would be forthcoming which the whole world could take and use.

Prof. R. B. Kleinschmidt outlined briefly the scope of the work being done at Harvard, incidentally describing the equipment and indicating the progress that had been made in the program laid out. The low-pressure region up to 200 lb. pressure had been covered, with the exception of a few points, but the high-pressure region had not been finished. Through the medium of lantern slides he showed the method of correcting for heat leak by plotting temperature difference against pressure difference and also by taking into account the effect rate of flow had on heat leak. Results obtained in the Joule-Thomson effect work up to the present time were summarized and comparison made with the values given in Collandar's "Properties of Steam" (1920), in the Heck steam tables and in the Davis curve.

Prof. H. N. Davis, also of Harvard, and co-author of the Marks and Davis steam tables, commented briefly on the work and made the promise to have in printed form by the first of the year what had been given out at the meeting. In the absence of Prof. F. G. Keyes, of the Massachusetts Institute of Technology, Professor Davis read his report, which described his portion of the work and compared the functioning of equipment he had used some years ago with present methods.

Dr. N. S. Osborne reviewed the program that the Bureau of Standards had undertaken to determine the thermal capacity of water as a saturated liquid as a basis for steam-table construction. A preliminary study of the calorimitry of a saturated fluid had been necessary. As to the progress made, the Bureau had produced a tentative design of apparatus appropriate to make the desired heat measurements and give simultaneously the heat content of the liquid, the latent heat and the specific volumes of the liquid and the vapor.

In the calorimeter one of the features was the design of a pump to circulate and agitate the water requiring only $\frac{1}{3{,}000}$ hp. to drive it. As work eventually turned into heat, it was important to keep the power down, so as not to introduce too high temperature measurements. From the pump designed, an efficiency of 40 per cent had been obtained. It had been no mean problem to pack it so that it would stay tight against pressures of 600 to 1,200 lb.

Up to the present the Bureau had not progressed far with the experimental equipment, but two things had been built and tried out successfully. This in conjunction with the experience that had been gained previously in determining the properties of ammonia, led to the expectation of good success in the measurement of water. For the greater part of the range an accuracy of 1 part in 3,000 was to be anticipated.

In the discussion attention was called to the happy combination that had been effected in the division of the work. The Massachusetts Institute of Technology was well equipped to cover high pressures; Harvard, the lower pressures and high superheat, and the Bureau, the saturated region. These simultaneous efforts, dovetailing nicely one into the other, gave hope that the work would go on rapidly to completion and soon be in shape to present to European engineers.

Research Papers

THIS session was held under the auspices of the Research Committee of the Society, with Walter Rautenstrauch as chairman. The papers this year covered a wide variety of subjects of which the following are abstracts. Of the five papers presented, two dealt with materials and two with flow meters.

Effect of Speed Upon the Strength of Gear Teeth

In his paper entitled "A New Method of Determining Effect of Speed Upon the Strength of Gear Teeth," Wilfred Lewis, who has long been known as an expert upon the subject, reviewed the history of gear-tooth research and then described a new type of apparatus with which it was hoped to obtain much-needed data on the subject. Of the early work he discussed that of E. R. Walker in the late 60's, the analytical work of Oscar Lasche, of Berlin, in 1899, and the elaborate experiments reported in 1912 by Professor Marx, of Stanford University. Of these, he said, only that of Lasche was based upon careful consideration of the theory. The constants given by Walker, while based upon practical experimental values for the upper and lower limits of speed, appeared to have been filled in more or less by rule of thumb for the intermediate points. In view of this Mr. Lewis was puzzled by the fact that the curves obtained by Professor Marx, of Stanford University, in 1912, corresponded closely to those of Walker and differed fundamentally from the curves given by Lasche. In spite of well-known and important discrepancies gear designers were still using the Walker rules, which were evidently well on the safe side for most conditions.

In view of this situation, Mr. Lewis considered it a matter of the first importance that further experiments be made to find the safe stresses for gear teeth at various linear velocities. To accomplish this, he suggested the use of an apparatus, proposed by Charles H. Logue and modified by himself, that made it possible to so run a pair of loaded gears that a curve could be automatically drawn showing the variations in velocity ratio. The author expressed the hope that the gear manufacturers and others interested in the question would be sufficiently impressed with the necessity of this work to raise the necessary funds to construct a large machine of this type and carry on an extensive series of experiments with it.

The closing paragraph of the paper made mention of the Research Committee on Gears appointed by the Council of the A.S.M.E. in 1921. This committee was constituted as follows: Wilfred Lewis (chairman), Earle Buckingham, Ralph E. Flanders, Arthur M. Greene, Jr., and Charles H. Logue, to which the following gentlemen have recently been added by the American Gear Manufacturers Association: F. E. McMullen and E. W. Miller.

All of those commenting on this paper agreed with the author as to the need for more research work with gears. It was pointed out that the curves of Walker were obviously not based on correct principles since they gave no limiting velocity, whereas it was well known that any given pair of gears had a limiting velocity beyond which it could not be safely operated, even when transmitting no power. This velocity ranged from less than 2,000 up to 10,000 ft. per min., depending on the type of tooth, pitch, clearances, workmanship, gear diameters, etc. Workmanship was one of the most important elements in determining the limiting speed, as evidenced by experience with turbine reduction gearing. Instead of a single curve being sufficient there was needed a whole series of curves covering various combinations of the variables mentioned.

Carl Barth, who has done pioneer work with various types of speed-changing mechanism, said that there was great need for a series of long tests to study the wear of gear teeth at working loads and speeds. Meanwhile, he said, designers should stick to the rules they knew until experience had proved the need of changes.

Another opinion expressed in the discussion was that tests to rupture were, after all, the most valuable. Mr. Lewis had looked upon such tests as untrustworthy, and had recommended in their place computations based on the inertia of the various moving parts and the experimentally determined variations in velocity.

Effect of Pulsations on Flow of Gases

By Horace Judd and Donal B. Pheley

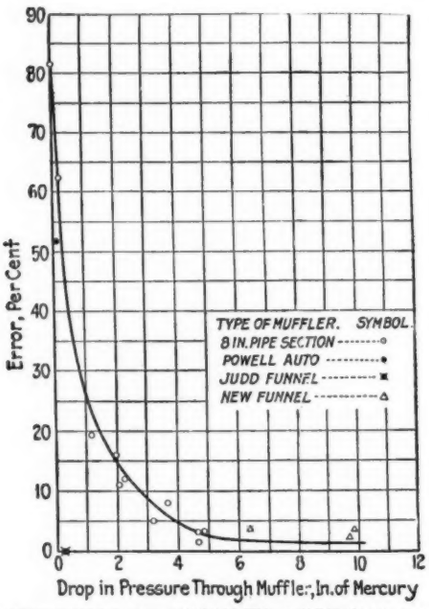
One of the most disturbing factors encountered in the metering of air, gas, steam and water, is that of turbulent or pulsating flow. All flow meters are based on laws that hold only for steady flow, so that puffs, waves or pulsations often result in errors that are of great magnitude and most difficult to adjust.

Early in 1920 experiments were started in the engineering laboratory of the Ohio State University to study the nature of this pulsation and to discover some practical means of reducing or eliminating it, or of compensating for its effect on the accuracy of venturi, flange-nozzle, orifice and pitot meters. Although experiments were made with air only and with a limited number of arrangements of apparatus, it is felt that the results probably have a broad application. The test layout consisted essentially of an air compressor with piping and places for the insertion of various tanks, mufflers, meters, etc. The pulsations in the air which came from the compressor were smoothed out by the use of a large tank or "volume," as it will be called hereafter. Beyond this there was an artificially rotated butterfly valve by which pulsations could be produced at any desired rate. Provision was made further along, for quieting these pulsations in various ways. The observations required were primarily of three kinds: First, measurement by means of carefully calibrated discharge orifices of the air discharge from the system; second, readings on the meter being tested, and third, study of the nature of the pulsations.

The first knowledge of the nature of the pulsations was gained through the use of an instrument that has been called the "photopulsometer." This instrument, is similar to the "phonodeik" designed by Prof. D. C. Miller and used by him in photographic studies of

musical sounds. Extensive experiments were also made with several steam-engine indicators located at various points of the system, and operated simultaneously.

The series of experiments led to the following conclusions: Pulsations consist of sudden changes both in the velocity and in the pressure of the fluid. The pressure change is more apparent and is probably the greater factor in producing errors in metering devices.



EFFECTIVENESS OF MUFFLER DEPENDS CHIEFLY ON PRESSURE DROP

This is in the form of a wave resembling a sound wave of low frequency. The pressure wave moves along the pipe with the velocity of sound, practically 1,000 ft. per sec. The effect of the pulsation on a flow meter is an increased reading that often causes an error of great magnitude. With orifice and flange-nozzle meters the error due to pulsation increases as the diameter of the orifice approaches that of the pipe. Throttling or modifying the manometer connection to the meter does not appreciably reduce the error. The pulsation must be eliminated or greatly reduced in order to have the meter read without serious error.

The experiments point to the following considerations in the practical elimination of pulsations: Because of the high velocity of the pulsations an excessive length of pipe line would be necessary to destroy them. Throttling is effective, but (under the conditions of the experiments) requires a pressure drop of 6 in. of mercury to reduce the error to 5 per cent. Abrupt enlargements in the pipe line will eliminate the error if of sufficient volume. Muffler devices combining throttling with volume are probably the most effective means of eliminating pulsations. The pulsating bag or diaphragm and the revolving fan are partially successful, but their installation is often impracticable. The effectiveness of the meter element itself in quieting the pulsation depends upon the degree of restoration of the pressure beyond the meter. The greater the percentage of restoration the higher the percentage of error shown for any given type of meter.

Discussion

J. M. Spitzglass, author of the paper on Orifice Coefficients, stated that while pulsation errors had long been known he was much surprised to hear of errors amounting to several hundred per cent. He felt that it was misleading to maintain a constant rate of flow in the experiment as the size of the orifice was increased. If, he said, the rate of flow had been kept in proportion to the area of the orifice, the percentage of error would have been much smaller. He doubted whether the error would ever exceed 25 per cent under the most extreme conditions found in practice. This could easily be handled by a moderate amount of throttling.

Orifice Coefficients—Data and Results of Tests

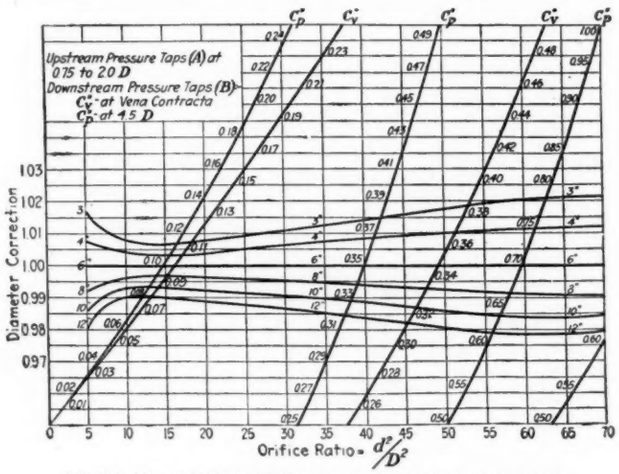
By J. M. Spitzglass

This paper gives the results of extensive experiments, conducted in the Research Laboratory of the Republic Flow Meters Co. on the use of orifices for measuring the flow of fluids in pipes.

In recent years the thin-plate orifice has been successfully applied to measuring the flow of fluids in pipes. At first orifices were used having an area small in comparison with the cross-sectional area of the pipes, so that the same coefficient could be used as for an orifice in a large tank. Practical developments have necessitated the use of orifices larger in proportion to the pipe size. Under such conditions the original laws no longer hold. Moreover, for a given flow the measured pressure drop depends upon the location of the pressure taps.

The experimental work was undertaken to determine, by actual test, the effect of varying the orifice ratio (orifice area divided by cross-sectional area of pipe), of changing the size of the pipe, and of shifting the up- and down-stream pressure taps.

The plan adopted was to compare the coefficient of the orifice undergoing test with that of "impact" tubes handling the same air and previously calibrated against


Upstream Pressure Taps (A) at 0.75 to 2.0 D
Downstream Pressure Taps (B)
C'v at Vena Contracta
C'p at 1.5 D
Diameter Correction
Orifice Ratio = d²/D²

ORIFICE COEFFICIENT C" FOR 6-IN. PIPE AND CORRECTION FACTORS FOR OTHER SIZES

standard orifices. In the apparatus, as finally erected, there were two vertical manifolds, one for inlet and the other for outlet. These were connected by seven long horizontal pipes of the following standard sizes: 2-in., 3-in., 4-in., 6-in., 8-in., 10-in. and 12-in. Each of these pipes contained a flange union into which could be inserted any one of fourteen different $\frac{1}{32}$-in.-thick Monel-metal orifices designed to give orifice ratios of

0.05, 0.10, 0.15 and so on up to 0.70. Seven upstream and twelve downstream pressure taps were provided in each case.

Connected to the vertical discharge manifold was a horizontal manifold holding five impact tubes for measuring the air discharge. These tubes had such a range of size that it was always possible to choose one suited to the orifice being tested. They were carefully calibrated by an extensive series of tests in which the impact pressure of the air leaving the impact tubes was compared with the pressure drop across standard orifices whose coefficients were known with great exactness. All of the tests were made with air furnished by a blower having a capacity of 6,000 cu.ft. per minute at a pressure of ten inches.

With this apparatus tests could be made in rapid succession because it was necessary to run only a few minutes to get constant conditions, after which instantaneous readings could be made of the desired pressure drops across the orifice and of the impact pressure at the discharge of the impact tube. [The original paper contains an extensive mathematical treatment of the flow through orifices under various conditions. It is not considered feasible to deal with that phase of the subject in the present abstract.—Editor.]

The tests showed clearly the importance of suitable location of the connections to measure the differential pressure across the orifice. While, with the data given, it is possible to find the coefficient for any desired location, it is desirable to choose such locations that a slight inaccuracy in drilling the holes will make practically no difference in the result. The original paper gives complete data on this for all sizes of pipe and for all orifice ratios.

From the point of view of the man who wishes to apply this information, the accompanying diagram should give practically all that is needed. In this the slanting lines give the discharge coefficients for a six-inch pipe using orifices of various ratios. The difference between C''_P and C''_V is only in the points where the pressures are measured. With the former the downstream tap is located $4\frac{1}{2}$ diameters from the orifice, while with the latter it is located at the "vena contracta." In both cases the upstream tap may be anywhere from $\frac{3}{4}$ to 2 diameters away from the orifice. In each case the coefficient is the figure by which must be multiplied the area of the pipe (not the orifice) and the theoretical velocity for the given pressure drop in order to get the rate of flow. After the constants have been read for a 6-in. pipe, they may be applied to other pipe sizes by using correction factors obtained from the horizontal curves and read on the scale at the left.

Discussion

As Chairman of the A.S.M.E. committee on fluid-meter research, R. J. S. Pigott called attention to the importance of the paper on pulsations, and that of Mr. Spitzglass, as part of the general research work which the committee would soon present in the form of an extensive report broadly covering the subject of flow meters. He then stated that the apparent discrepancies between the earlier experiments made with orifices were due almost entirely to the fact that the effect of the location of the manometer taps had not been duly considered. Mr. Spitzglass, he said, had made all these results consistent with one another and with his own experiments, by taking full account of this factor. As a result the general confidence in flow meters would be greatly increased. He went on to say that practically all types of flow meters would give accurate and consistent readings if properly installed.

In reference to pulsation Mr. Pigott stated that engineers must frankly recognize this source of error. The proper angle of attack seemed to be from the standpoint of acoustics.

In reply to a question Mr. Spitzglass said that the results obtained with air were generally applicable to flow meters measuring steam, water and other fluids. In further discussion the son of the author suggested that the single diagram (here shown) of orifice coefficients be replaced by a series of curves for the various sizes of pipes.

Effects of Sudden Steam Discharges

The fear has been expressed from time to time by various engineers that the sudden popping of a safety valve of large capacity may set up forces in the boiler which tend to strain it. These fears are entirely unfounded if we may judge by the results of tests carried out by the Research Sub-committee on "Sudden Initial Pop Lift of Safety Valves." As reported by the committee, these tests showed no measurable pressure increase at any point in the boiler, due to the safety-valve blowoff, even when special valves were used giving a rate of discharge nearly twenty times as much as would be obtained in the case of a boiler fitted with standard safety valves of the capacity required by the A.S.M.E. Boiler Code.

An extremely sensitive pressure indicator of special design was used, the inertia of the moving parts of the steam-engine indicator being too great to give conclusive results. The type of pressure indicator employed was one in which a thin phosphor-bronze diaphragm with a maximum permissible movement of 0.007 in. was so mounted that it could be held in equilibrium between the boiler pressure on one side and an adjustable air pressure on the other. When equilibrium had once been established (by adjusting the air pressure), the slightest increase in boiler pressure at the point of attachment moved the diaphragm in such a way as to close an electrical contact and light a small signal lamp.

Four of these indicators were attached to a horizontal water-tube boiler at the following points: (1) In the tube header opposite the upper end of the center tube of the lowest row; (2) similarly located opposite the upper end of the center tube of the top row; (3) at the end of 10 in. of $\frac{1}{4}$-in. pipe leading horizontally into the front tube header 15 in. below its top edge; (4) vertically into the Y fitting at the top center of the drum. This Y fitting was used for attaching two valves, one of which was the regular safety valve of the boiler, while the other was the special high-capacity adjustable-pop valve used for the tests. These locations were chosen as those most likely to show presence of "shock" pressures.

Since not the slightest increase of pressure was measurable at these points, the committee considered it unlikely that any appreciable shock would have been found at other points in the boiler tested or in other boilers.

The principal tests carried on by the committee were made at Bridgeport, Conn., but were similar to, and showed the same results as, thesis tests along this line

by C. W. Greening, W. W. Harris and J. K. Macomber, senior students at the Massachusetts Institute of Technology.

The members of the A.S.M.E. sub-committee that carried on the final experiments at Bridgeport are: P. G. Darling (chairman), E. F. Miller, W. E. Jerauld, G. H. Clark, I. E. Moultrop, A. M. Houser, A. L. Fitch and G. S. Coffin.

This paper brought out no discussion other than expressions of satisfaction that the question investigated had been settled beyond the possibility of dispute.

The Torsion of Crankshafts

Dr. S. Timoshenko, consulting engineer with the Vibration Specialty Co., who presented a mathematical paper covering the elements of the theory of the torsion of crankshafts, has long been known as an expert on the applications of the theory of elasticity, having held professorships on this and closely allied subjects in various European universities.

"The time has passed when engine design comprised merely the application of statics, and more attention is now paid to the fact that in various types of engines there is not even an approximation of a state of equilibrium," he said in introducing the subject. "The problem is no longer one of statics, but concerns the dynamics of an elastic system." Dr. Timoshenko went on to show that calculations made on the basis of the impressed forces alone must lead to erroneous results.

In connection with reciprocating engines, he said, it was first necessary to determine the torsional properties of the crankshaft, the subject dealt with by this paper. The subject was so complex that a mathematical solution was impossible unless certain simplifying assumptions were made. For example, certain parts of the shaft were considered to be elastic and others, such as flywheels, armatures, etc., were assumed to be absolutely rigid. With these assumptions, the engine could be reduced to a system of flywheels situated on a shaft of uniform diameter. This shaft, called the "equivalent shaft," had an arbitrary diameter, but its length between each two flywheels was such that it was equivalent (as to torsion) to the actual shaft between corresponding parts of the actual engine.

After developing the simple formula for the torsion of a straight shaft, the writer proceeded to the more involved condition found where the straight run of the shaft is broken by a crank. Only the single-throw crankshaft was considered in this discussion. As a preliminary to the more general formulas Dr. Timoshenko developed formulas for the rigidity in torsion and bending of the "equivalent shaft," journal, and crankpin. With these as the foundation, he considered various cases defined by the degree of restraint that the bearings imposed upon the journal, this in turn depending largely upon the clearance. The first case considered was that of no constraint, while the second was that of complete constraint corresponding to no clearance. After that the case of partial constraint was considered. The paper closed with numerical examples and an appendix, giving among other things a series of equations for the potential energies represented by bending, torsion and shear in the crankpin, web and journal.

A number of lantern slides were shown of photographs not given in the printed paper. These were oscillograms showing the instantaneous variations in the torsion of a Diesel-engine crankshaft at its point of attachment to the rotor of an electric generator. One of these showed momentary torsions as high as twenty times the average computed from the speed and power at full load. These diagrams were of particular interest, in that they showed the value of similar methods of investigation in such diverse studies as pulsation in fluids and torsion of crankshafts.

General Papers

IN THIS group are a number of papers touching upon a variety of subjects, such as thickness of refrigerating insulation, the size of vacuum pumps, ash handling and a number of other contributions of a more technical nature. All of these papers are of general interest to the field and the brief summaries following will indicate their specific value.

Determining Size of Dry-Vacuum Pump

By Edward W. Noyes and Harold V. Sturtevant
Sales Engineers, Sullivan Machinery Company

In pumping from atmospheric pressure down to a given vacuum with a dry-vacuum pump, as during the process of exhausting a closed tank, the volumetric efficiency of the pump varies from that of atmospheric pressure to that corresponding to the given vacuum, and an average value has to be determined to use in the theoretical formulas that apply to this kind of service.

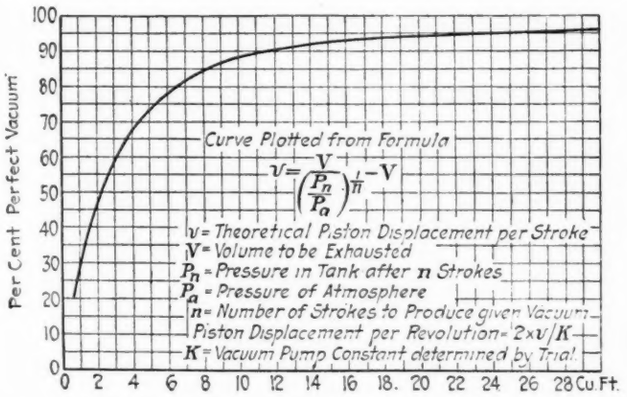
Two methods of determining the average volumetric efficiency were successfully tried out and the results plotted in the form of curves, but these results did not check satisfactorily with those obtained in actual tests of installations. The process of calculation employed in the second (and somewhat more accurate) method was then reversed, and working with actual test data, values were obtained from which a "constant" curve was plotted, this curve giving closely accurate results from 80 per cent perfect vacuum up. With the aid of this "constant" curve two charts have been plotted, by means of which it is possible to determine rapidly and with sufficient accuracy (1) the size of pump required to exhaust a given volume to a specified degree of vacuum in a predetermined time; or, (2) where a vacuum pump is already installed, the time required to exhaust a given volume to a specified degree of vacuum.

These two curves are reproduced in Figs. 1 and 2. The former applies to problems in which the total revolutions or r.p.m. and time are known or assumed, and it is desired to calculate the piston displacement necessary to exhaust a given volume to a predetermined vacuum.

Fig. 2 will apply to cases where the displacement of the pump is assumed or known and it is desired to find the total number of revolutions required to exhaust a given volume to a predetermined vacuum. Knowing the time that may be required in the process, the r.p.m. of the pump may be obtained. A barometric pressure of 29.5 in. was used in the computations, and the

results were plotted against percentage of perfect vacuum, so that the curve will apply with any barometric pressure. In using the curves the average barometric pressure over a long period of time in any given locality should be used. Knowing the degree of vacuum desired, the percentage of perfect vacuum can be readily calculated.

To illustrate the application of the curves, the accompanying typical cases are worked out. The first and most important is the case where it is desired to determine the size of pump required to exhaust a given volume to a certain degree of vacuum in a predetermined time. This problem may be approached from two different angles—the r.p.m. of the pump may be assumed and the required piston displacement per revolution determined, or the piston displacement per revolution may be assumed and the total revolutions or r.p.m. calculated.


Per Cent Perfect Vacuum
Curve Plotted from Formula
$v = \frac{V}{\left(\frac{P_n}{P_a}\right)^{\frac{1}{n}} - V}$
v = Theoretical Piston Displacement per Stroke
V = Volume to be Exhausted
P_n = Pressure in Tank after n Strokes
P_a = Pressure of Atmosphere
n = Number of Strokes to Produce given Vacuum
Piston Displacement per Revolution = 2xv/K
K = Vacuum Pump Constant determined by Trial
Cu.Ft.

Piston Displacement per Revolution required to Exhaust a Volume of 1000 Cu.Ft. from Atmospheric Pressure to any Per Cent Vacuum with 300 Revolutions. (For a Different Volume or Number of Revolutions the Piston Displacement varies Directly as the Volumes and Inversely as the Revolutions.)

FIG. 1—DRY VACUUM PUMP DISPLACEMENT REQUIRED TO EXHAUST A CLOSED SPACE

I—Given a volume of 5,000 cu.ft., including the piping between the pump and tank, it is desired to find the size of pump required to exhaust the tank to a vacuum of 26 in. in 30 min. Barometer, 29.5 in.

a. Assume that the pump will run at 280 r.p.m. In this case the percentage of perfect vacuum $= \frac{26}{29.5} = 88.1$ per cent. Using the chart of Fig. 1, follow the line at 88.1 per cent horizontally until it intersects the curve, then vertically downward to the base line, when the piston displacement will be found to be 10.15 cu.ft. This is the piston displacement per revolution required to exhaust 1,000 cu.ft. from atmospheric pressure to 26 in. with 300 revolutions of the pump. Hence

$$\textit{Displacement per revolution} = \frac{10.15 \times 5{,}000}{1{,}000} \times \frac{300}{280 \times 30} = 1.812 \textit{ cu.ft.}$$

This is the actual piston displacement required with a pump running at 280 r.p.m. to exhaust 5,000 cu.ft. to 26 in. in 30 min. Allowance has been made for leaks such as are always present in the average installation. For excessive leakage, however, a small factor of safety may be added.

b. Assume the piston displacement per revolution = 2 cu.ft. Using chart of Fig. 2 follow the line at 88.1 per cent horizontally until it intersects the curve; then vertically downward to the base line, where the number of revolutions is found to be 305. This is the total number of revolutions required to exhaust a volume of 100 cu.ft. from atmospheric pressure to 26 in. with a pump of 1 cu.ft. displacement per revolution. Hence

$$\textit{Total revolutions} = \frac{5{,}000}{100} \times \frac{305}{2} = 7{,}625$$

$$\textit{R.p.m.} = \frac{\textit{Total revolutions}}{\textit{Time in minutes}} = \frac{7{,}625}{30} = 254$$

This is the actual r.p.m. required with a pump of 2 cu.ft. piston displacement per revolution to exhaust 5,000 cu.ft. to 26 in. vacuum in 30 min.

The second type of problem, the solution of which may be obtained by use of the curves, is the one in which a vacuum pump is already installed and it is desired to determine the time required to exhaust a given volume to a certain degree of vacuum.

II—Given an 18 x 8-in. pump running at 300 r.p.m., how long will it take to exhaust a tank of 2,500 cu.ft. capacity from atmospheric pressure to 26 in. vacuum? Barometer, 28.4 in. Piston displacement per revolution = 2.34 cu.ft.

Percentage of perfect vacuum $= \frac{26}{28.4} = 91.5$ per cent.

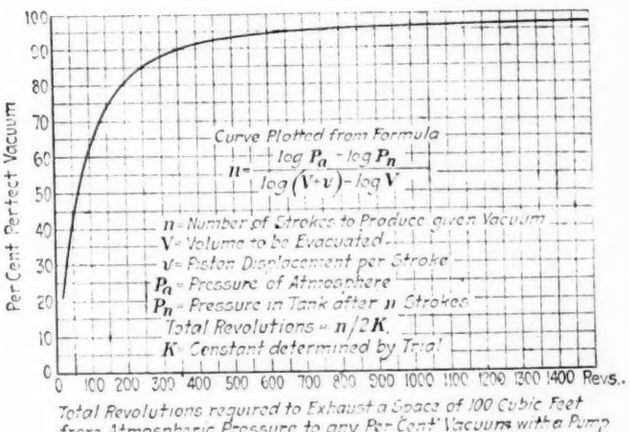
Using Fig. 2, follow the line of 91.5 per cent horizontally until it intersects the curve, then vertically downward to the base line, when the revolutions are found to be 415. This is the total number of revolutions required to exhaust a volume of 100 cu.ft. from atmospheric pressure to 26 in. with a pump of 1 cu.ft. piston displacement per revolution. Hence,

$$\textit{Total revolutions} = \frac{2{,}500 \times 415}{100 \times 2.34} = 4{,}433.8$$

$$\textit{Time required} = \frac{\textit{Total revolutions}}{\textit{R.p.m.}} = \frac{4{,}433.8}{300} = 14.8 \textit{ min.}$$

This is the actual time required, allowance having been made for leaks such as are present in the average installation.

In presenting this method of solving problems concerning the evacuation of closed spaces, the authors do not claim to have produced an absolutely accurate rule which will answer in every case. They do hold, however, that the method proposed, of using a constant determined by trial, gives much more accurate results than can be obtained by the use of an average volumetric efficiency computed by either of the two methods mentioned in the paper.


Per Cent Perfect Vacuum
Curve Plotted from Formula
$n = \frac{\log P_a - \log P_n}{\log (V+v) - \log V}$
n = Number of Strokes to Produce given Vacuum
V = Volume to be Evacuated
v = Piston Displacement per Stroke
P_a = Pressure of Atmosphere
P_n = Pressure in Tank after n Strokes
Total Revolutions = n/2K
K = Constant determined by Trial
Revs.

Total Revolutions required to Exhaust a Space of 100 Cubic Feet from Atmospheric Pressure to any Per Cent Vacuum with a Pump of One Cubic Foot Piston Displacement per Revolution (For Different Volume or Piston Displacement the Total Revolutions vary Directly as the Volumes and Inversely as the Piston Displacement.)

FIG. 2—DRY VACUUM REVOLUTIONS REQUIRED TO EXHAUST A CLOSED SPACE

Thickness of Insulation in the Refrigerating Field

By P. Nicholls

The factors to be considered when figuring on the thickness of insulation that it is best to use, are in general well understood. The method that is usually employed is that of a trial of several thicknesses to find what advantages result, and though the term "economic thickness" is well known, there is apparently no published formula for its value that takes into account all the factors.

Trial calculations are rather laborious, more liable to mistakes in computation, and the detail of the work tends to hide the general principles involved or to give undue weight to one factor. The better plan would seem to be to thrash out the principles thoroughly and to develop a general equation which was done by P. Nicholls, author of this paper.

Although the problem is simple in its main consideration, it becomes complicated when considered in a more exact method, and the various reactions that occur as the insulation thickness is varied, are taken into account. Any answer can be correct only in so far as true numerical values can be given to all the reactions, and as this sometimes involves predictions as to the success of the business and other uncertain features, an empirical rule may often be as good as an attempt to fix exact values.

The economic thickness for a heat insulation is that which will reduce to a minimum the sum of the expenses due to the heat passed through it plus the expenses of prevention.

The author developed several equations covering walls, tanks, piping, etc.

It was not his purpose to recommend definite thickness, but rather to establish a standard of reference and to set out a basis of argument on which the figuring of the thickness may be done.

In spite of this it is advisable to have an agreed standard method of computation to refer to in cases of dispute, and on which to base practical rules; and if such agreement can be expressed as a definite formula, then the problem is reduced to fixing the values of the various symbols. This is sometimes more difficult than agreement as to the method, but at least it focuses the attention at the correct point.

Discussion

C. H. Herter, in discussing the paper, stated that he felt that the method proposed by the author was somewhat complicated and necessarily required a knowledge of costs of both insulation and of refrigeration. Since in a great many cases these costs are not known, it was not possible to apply Mr. Nichols' formula. He gave a single method which, so he stated, some years of experience had proved to be commercially satisfactory. The rule was as follows:

For the average plant where the cost per ton of refrigeration amounts to $2.50 per ton, provide one inch of pure corkboard, or the equivalent, for every 15 deg. F. temperature difference. Where refrigeration is very cheap, allow one inch of corkboard per 20 deg. difference, and in case of expensive refrigeration allow one inch for each 10 deg. Mr. Herter claimed that on the basis of his calculations it appeared to be advantageous to pay for one square foot of insulation one-fourth to one-fifth of the total cost per ton of refrigeration. Another rule given by Mr. Herter was to the effect that the insulation should be such as to reduce the heat loss per square foot per 24 hours to 1.5 B.t.u. with refrigeration at $2.50, and 2 B.t.u. with $1.50 refrigeration.

Prof. A. J. Wood, of Penn. State College, pointed out that the importance of the subject was brought to his attention when testing refrigerating cars at Penn. State College.

The investor is concerned with two questions. First, what is the economic thickness, and second, what is the saving that would result from the adoption of the correct thickness? Mr. Wood felt that Mr. Nicholls offered a neat solution of the first problem. The question often came up as to the advantage of say putting in 3-in. insulation when 2½-in., the economic thickness, was not commercially available, in preference to installing 2-in. insulation. The charts given, while correct for a particular plant, cannot be used for all.

The engineering experiment station, Penn. State College, had found it an advantage to plot "cost-thickness" curves. In this way not only was the economic thickness found, but also the saving that would result from the adoption of the correct thickness as compared to any other thickness.

He agreed that the practical economic thickness was not an exactly definite thickness. One should choose a thickness near the economic thickness, but conforming to some multiple of standard thickness of commercial materials. Extreme accuracy is not necessary, since 10 to 15 per cent error does not appreciably affect the figure for annual cost.

Stresses in Cylindrically Shaped Rotors

To the designing engineer who is responsible for fixing the physical dimensions and proportions of high-speed rotary machinery, such as steam turbines, turbo-alternators, high-frequency generators and various other classes of electrical machines, a knowledge of the magnitude of the rotational stresses due to centrifugal force is of prime importance, so that the paper on the subject by C. M. Laffoon, who is connected with the Engineering Department of the Westinghouse Electric and Manufacturing Co., should be regarded as a valued contribution, particularly as it fills a long-felt need by electrical engineers for a more complete and comprehensive analysis of these stresses than is usually given in handbooks.

In presenting the physical conception and analysis of the stresses, the author bases the derivation of the fundamental equations upon the method used by Stodola in analyzing stresses in rotating disks of steam turbines. The general equations are derived and applications to seven different types of cylindrical rotors are analyzed and the formulas for these cases developed.

In the case of solid rotating cylinders it was brought out that the greatest radial elongation occurred at 90 to 95 per cent of the radius and not at the extreme surface. The equations indicated that when an axial hole exists in a solid rotating cylinder, the stresses are at least doubled, which would hold good for as small a diameter as 0.001 of an inch.

Discussion

This point was covered in an interesting manner in the discussion. A. A. Adler described conditions in a rotor which is brought above speed to a point where some parts are stressed beyond the elastic limits. A

flow of metal tends to take place, which distributes the maximum strain to some extent. After it is brought back to a condition of rest, the rotor is in a different physical condition than before, so that it is in a somewhat better condition to stand normal speeds, as a result of the flow that has taken place in the metal, allowing a lower maximum stress. The elastic qualities have, naturally, been changed in the parts that were stressed above elastic limits.

Stress Distribution Visualized By the Photo-Elastic Method

In a paper entitled "Stress Distribution in Electric Railway Motor Pinions as Determined by the Photo-Elastic Method" by P. Heymans and A. L. Kimball a novel process is described. The actual distribution of stress in a bas of steel that is placed in flexure cannot be calculated accurately by mathematics on account of the conditions of flexibility, and non-uniform structure of the metal, which govern the precise distribution of the stresses that are set up. A bar of celluloid, however, may be bent, and the actual stresses can be thrown in colors on a screen by means of polarized light, which shows clearly the location of the neutral axis as well as maximum stresses. By carefully plotting the lines of color, it is possible to estimate the unit stress that takes place.

The colors, however, may be taken as a general guide in visualizing the actual conditions. When a bar is bent, the neutral axis, where no stress occurs, will appear as a dark band across the middle. Colors on each side of this axis will extend in yellow, then red, and finally violet bands at the extreme edges, where maximum compression or tension is produced. If a small crack exists across a piece of metal in tension, the extreme forces set up can be readily shown, and when a fairly large hole is drilled at the end of the crack, these forces are reduced to about one-fourth of the area originally occupied by them. An interesting discussion of the application of this method followed the reading of the paper.

Flywheels for Motor-Driven Impulse Wheels

The investigations by C. O. Rhys, the author, refer to the size of flywheels and capacity of motors required for performing cycles of work, such as are required for punches or shears, where the flywheel must assist greatly in the working stroke and receive energy from the motor both between and during the working strokes. The equations developed by the author, which are carefully presented in mathematical form and which are derived in the various appendices, refer to the curves of energy supplied by the flywheel and that received from the motor. The load may be applied under any chosen condition of speed and the resulting effects on the motor and flywheel calculated for succeeding conditions.

Torque and speed curves are analyzed, and the author has described a method of checking the results of such formulas by means of recording curves that take place in an actual mechanism, for which a special form of recording dynamometer is utilized.

Conditions are mainly discussed in which a comparatively small drop in speed of the flywheel is required. It is assumed that the current supplied by the motor is proportional to the slip for the short speed drop that the motor undergoes in imparting energy to the flywheel. The load-resistance curve may represent any desired function of time.

The author has given a set of formulas that should be used when the curve of motor torque does not lag more than 15 deg. behind the curve of required load resistance. In case a greater lag is encountered, special formulas must be used, as given in an appendix.

Discussion

There were no written discussions submitted. Remarks were made by E. H. Thompson, A. A. Adler, A. L. Kimball and S. A. Morse. It was brought out that special formulas which were given for cases where the curve of motor torque lagged more than 15 deg. behind that of the flywheel, referring to the curves of motor and flywheel torque, could be used where excessive lags existed. Where unusual loads and great slowing down occurs, these formulas would be sufficient for very excessive slips, such as cases where the flywheel was decreased from 10 to 20 per cent in speed, assuming a straight-line relation of motor slip to torque. The article considered that the torque of the electrical motor was proportional to slip. This was considered to hold for the curves of direct-current shunt-wound motors, as well as alternating-current motors, provided the working cycle was at small motor slip portion of the curve, where it approximated a straight line.

Ash Handling*

In a paper by John Hunter and Alfred Cotton ash-conveying systems for marine work are first described in a brief manner, as such systems were originally used aboard ship. These generally refer to the injector type, which uses a jet of water actuated by steam for washing the ashes overboard either above or below the water line.

A large number of examples of ash conveying and storing apparatus for stationary boiler plants are given. In the latter case conditions vary widely in regard to stokers, direction and elevation required for conveying ashes, and the means at hand which can be most readily utilized for conveying apparatus, so that no general example of a universally applicable complete system can be cited.

This paper, with the exception of a few interesting figures, does not include costs of equipment, maintenance or labor in connection with such devices. So many circumstances enter into each particular problem that costs for comparative purposes must be used with great caution. Experience and judgment are therefore considered to be of more value than absolute figures.

Hopper ashpits are first taken up, many examples are given and the conclusions on which design and operation should be based are cited. Sufficient storage capacity, means for quenching with water, methods of controlling the draft leakage, together with proper slopes for ashpits, are described. Mechanical conveyances are reviewed from rudimentary methods to those of the most modern installations, such as the Hell Gate plant, which uses a water ash conveyor. One of the objections of mechanical conveyors is the abrasive qualities of the ash carried.

*A full abstract will appear in a later issue.

Air conveyors, otherwise known as steam-jet conveyors, are described in great detail, giving some figures of actual operation.

Possible future changes or plant conditions have a very important bearing when deciding on conveying apparatus.

Discussion

The discussion that followed this article brought out the point that while in large power houses the three principal material-handling problems were water, coal and ashes, the first two have been quite satisfactorily reduced to a scientific basis, but ash handling represents the most difficult and elusive of the three. The amount of ashes may vary beyond expectations, due to using poor coal in emergency conditions; added to this is the question of ash disposal, which becomes more serious with many plants as the available ash dumps near the plant become filled up.

Eugene Hahn advised that one objection to the use of a water jet for the removal of ashes aboard ships is the comparatively large amount of steam that is lost in being condensed and discharged overboard. The makeup water is a very serious problem, and ashes can be successfully conveyed with a greatly reduced amount of steam by using a steam air jet, with a well-designed turbine-type nozzle. Sea water can be used for wetting the ashes to prevent them from causing annoyance to the ship. For burning 500 tons of coal, 60 tons of ashes must be removed, which can be done with 7,200 lb. of water with steam conveyors using properly designed nozzles. A ship of this kind ordinarily carries 300 tons of fresh water in tanks, so that water for ash disposal representing 3½ tons is approximately 1 per cent of the water carried in tanks. It is expected that such a system would save from 2 to 5 per cent of the coal burned during the voyage on account of the higher efficiency of the work done in disposing of the ashes.

T. A. Marsh dwelt on the design of ashpits, stating that this has caused many stoker failures. Water sprays for keeping down the temperature of the ashes are of prime importance. Cost of operation can be greatly reduced in some cases by the use of remote control systems. Small manufacturers who seldom rebuild plants are usually the worst offenders in the matter of improper design of ash pits and handling apparatus.

F. B. Allen described the use of water sprays for quenching ashes instead of the usual perforated pipes. He advised continuous quenching and showed methods of cleaning the sprays without affecting the operation. R. H. Beaumont spoke at length on ash handling from the point of view of one who has had many years' experience in repairing systems of this kind. It appears that the nature of the ashes to be handled is seldom properly looked into. In general, it does not pay to try extensively to prevent the wear of metal by ashes. It is cheaper to make replacements instead. A cast-iron ashpit supported by steel straps seems to be a practical solution.

N. E. Funk stated from the point of view of the operator that low maintenance and repairs was one essential requirement; the possibility of substituting similar apparatus in case of a breakdown was another, and flexibility of operation which allowed a large overload to be carried with proportional increase in operating expenses but without great additional duplicate apparatus, are desired. Large ashpits, which can be emptied by railroad cars or industrial cars, represent a desirable combination. With very little trouble the number of cars can be readily increased to take care of overload, while horses or trucks can be substituted in case of serious car breakdown in transportation. Abrasion due to the hard character of the ashes is a great problem in all systems of mechanical or air or water conveyors. C. E. Prout described telescopic hoists to be used for ashpits for small plants below the level of the streets. With a 20-ft. lift 78 cans, 24x17 in., with each containing three bushels, can be raised on one kilowatt-hour of electricity.

N. W. Elmer called attention to the future of ash disposal in relation to powdered fuel, since it appears that the latter method of burning fuel is rapidly gaining headway. I. E. Moultrop considered that the disposal facilities represented the biggest problem, as many plants have gradually exhausted the available dumping spaces which made expensive hauls necessary. T. Maynz spoke of the desirability of large ashpit storage rooms in order to take care of breakdowns.

G. G. Bell described the water-sealed ashpit of the Springdale plant of the West Penn Power Co., which has a storage capacity of three days. He showed slides of the ashpit conveying system of the Windsor plant, where ashes are dumped into a ravine which at present represents a capacity sufficient for ten years of operation. The ashpit in the new addition of the Windsor plant has a storage capacity of ten days with three possible systems of disposing of the ashes. E. F. Libbey described the electrical ash conveyors specially suitable for small plants, stating that a great deal of education is necessary among small plant owners where such devices could be used. E. H. Tenny described a few requirements of small plants in regard to handling systems. W. F. Hunt, chairman of the committee, who has developed a formula relating to the cost allowable for ash-handling systems, submitted the findings of the committee.

Hearings on Boiler Code

The hearings of the Boiler Code Committee commenced on Monday morning with one devoted to the revision of the Code for power or high-pressure boilers. The session was characterized by the interest manifested by various groups. For instance, that of the safety valve manufacturers, who discussed the limitation of the blowdown and multiplex casing; that of the manufacturers of oil country boilers who desired the restrictions upon the diameter of the dome to be made not less than 60 per cent. A group of state and municipal inspectors reopened the question of stamping. There was an extended discussion on the proposed specifications for pipe and fittings, particularly with reference to the thickness of pipe walls.

Quite a number had attended for the purpose of discussing the Code for Unfired Pressure Vessels, for which no public hearing had been announced, and they were afforded an opportunity to present their discussion.

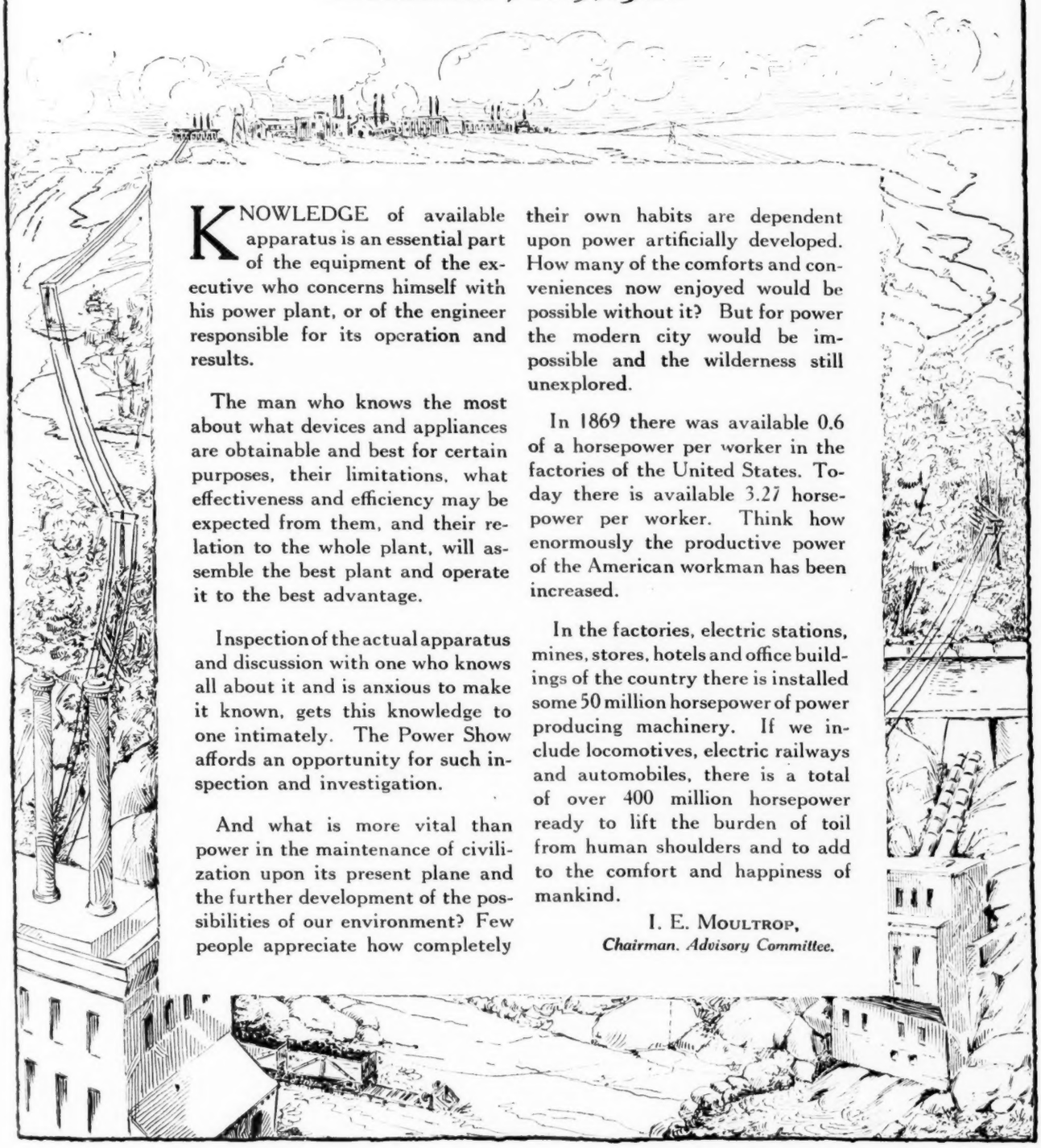
On Tuesday the hearing was devoted to the consideration of the Code for Low-Pressure and Heating Boilers, and was largely occupied by the representatives of the welding interests in a protest against the provision for preheating seams which were to be welded.

[Owing to lack of space in this report section, the paper on "Design of Cooling Towers" and those on "Education and Training for the Industries" will be printed in a subsequent issue.—Editor.]

NATIONAL EXPOSITION of POWER AND MECHANICAL ENGINEERING

Grand Central Palace New York City

December 7 to 13, 1922



KNOWLEDGE of available apparatus is an essential part of the equipment of the executive who concerns himself with his power plant, or of the engineer responsible for its operation and results.

The man who knows the most about what devices and appliances are obtainable and best for certain purposes, their limitations, what effectiveness and efficiency may be expected from them, and their relation to the whole plant, will assemble the best plant and operate it to the best advantage.

Inspection of the actual apparatus and discussion with one who knows all about it and is anxious to make it known, gets this knowledge to one intimately. The Power Show affords an opportunity for such inspection and investigation.

And what is more vital than power in the maintenance of civilization upon its present plane and the further development of the possibilities of our environment? Few people appreciate how completely their own habits are dependent upon power artificially developed. How many of the comforts and conveniences now enjoyed would be possible without it? But for power the modern city would be impossible and the wilderness still unexplored.

In 1869 there was available 0.6 of a horsepower per worker in the factories of the United States. Today there is available 3.27 horsepower per worker. Think how enormously the productive power of the American workman has been increased.

In the factories, electric stations, mines, stores, hotels and office buildings of the country there is installed some 50 million horsepower of power producing machinery. If we include locomotives, electric railways and automobiles, there is a total of over 400 million horsepower ready to lift the burden of toil from human shoulders and to add to the comfort and happiness of mankind.

I. E. MOULTROP,
Chairman, Advisory Committee.

Glimpses of the Power Show

Much New Equipment Evident—Splendid Program of Motion Pictures—Educational Value of the Exhibits—Models Prove Centers of Attraction

ONE of the big events on the engineer's calendar for December has at last become a reality, and today finds a host of members of the profession passing through the doors of Grand Central Palace, for a look at the first National Exposition of Power and Mechanical Engineering.

Although the visitor may be struck with the general predominance of power-plant auxiliaries, accessories and special devices, to the almost complete exclusion of boilers and prime movers, this should reflect no discredit on the exposition or on its management, for an exhibition of the larger factors in power generation would be almost prohibitive in cost, to say nothing of the labor involved in transporting and setting up the heavier pieces of equipment. For the first of its kind, the Show has done remarkably well and is deserving of the greatest success.

Models Show Station Practice

No matter how grown-up and dignified we may consider ourselves, who is there among us who does not delight in the performance of a toy counterpart of some large and familiar object, faithfully reproducing on a small scale the functions of its bigger brother? The Show had not been open an hour before a large crowd was to be found around each of the exhibits wherein are shown models of the various devices entering into the process of taking coal from the mine, handling it at the power plant, turning it to steam, using the steam to generate electric power and sending the power out through transmission lines to the consumer. In a centrally located space one finds a model of the famous Loree breaker of the Hudson Coal Co., which shows clearly the manner of preparing anthracite for the market. The entire series of operations—crushing the large lumps of coal, sizing it through screens and passing the sized coal to jigs, where the refuse material is separated out—is shown in miniature.

The development of the power station itself is portrayed by a series of models of the important central stations in New York City. The original station erected by Thomas A. Edison in Pearl Street appears beside the more modern Waterside stations, showing vividly the great advances in power-plant design since the day of the "jumbo" generator and the earlier types of reciprocating engines.

But no visit to the show could be considered complete without a look at at least a few of the many entertaining as well as instructive motion pictures. The program, an exhaustive one, was made up with the co-operation of the United States Bureau of Mines and of various manufacturers, with the idea of providing films that would bring novel and important information to the layman as well as to one technically trained.

With a keen appreciation of the educational value of the many exhibits, the management is extending a warm welcome to students of engineering. Special facilities have been offered for organized classes from Yale University, Brooklyn Polytechnic Institute and Princeton University to visit the Show in a body, and rooms have been set aside for lectures about any of the material displayed. In this manner it is hoped to give the student an intimate contact with the practical application of the various types of engineering apparatus. The exhibitors are co-operating in this respect by having on hand properly qualified representatives capable of explaining fully any technical questions arising in connection with their exhibits.

Those interested in power-plant cost accounting (and we all should be) will naturally gravitate toward the exhibit of the Republic Flow Meters Co., where complete forms of the company's system of power-plant cost accounting are being shown and explained, with special reference to the application of steam-flow meters to the problem. Another interesting feature of the exhibit is the presentation in chart form of the data contained in one of the papers read at the A.S.M.E. annual meeting—that of J. M. Spitzglass, vice-president of the Republic company, on "Orifice Coefficients."

From the oil well to the engine-room storage tank is a long and eventful journey, says the Tide Water Oil Sales Corporation. And at its booth the company proves this statement by an interesting little daylight moving-picture exhibit called "The Story of Tide Water Oil," which takes the beholder on a fifteen-minute trip through the entire petroleum industry. Besides this educational feature there is an animated comedy by Tony Sarg. The plot starts in the engine room. Trouble is brewing, and the engineer knows it. He knows the reason—improper lubrication. And right here is where—but, as the company says, the rest is too good to give away and must be seen to be appreciated.

The need for greater knowledge of combustion among power-plant operating engineers is manifest, and the Hays School of Combustion seeks to fill that need by a home-study course in combustion, created to promote the more efficient use of fuel as well as to aid in the advancement of those who handle it. Full information on the course will be found at the Hays booth.

Fuels and Stoking Equipment

There has been continued interest in recent months in the growing use of powdered coal as a boiler fuel. Pulverized coal is now conceded to have passed finally and unquestionably from the experimental stage to the class of the commercial steam-boiler fuel, as is attested by the appreciable number of plants that have converted their boilers to this form of fuel.

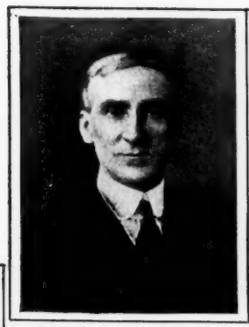
Of outstanding interest among the exhibits devoted to powdered-coal equipment is that of the International Combustion Engineering Corp., where will be found the Lopulco system for burning pulverized coal. Burners and feeders are exhibited, while blueprints show construction details of many of the company's typical installations. The Combustion Engineering Corporation and Green Engineering Co., subsidiaries of the International corporation and occupying space adjacent to the Lopulco exhibit, are showing complete lines of Frederick, Type E, Coxe and hand stokers and Green chain grates.

In spite of the attention now being given powdered coal, it must not be supposed that stoker manufacturers have been sitting idly by. The Sanford Riley Stoker

THE ADVISORY COMMITTEE

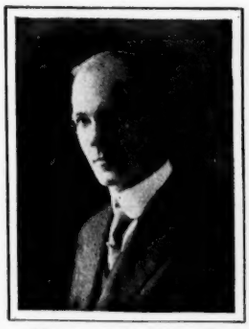
National Exposition of Power and Mechanical Engineering

N. A. CARLE
VICE-PRESIDENT
PUBLIC SERVICE PRODUCTION CO
OF NEW JERSEY

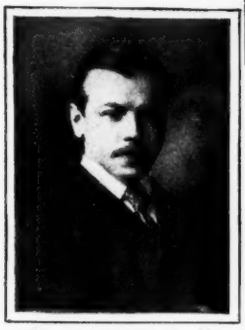


DEXTER S. KIMBALL
PRESIDENT
A.S.M.E.

CALVIN W. RICE
SECRETARY
A.S.M.E.

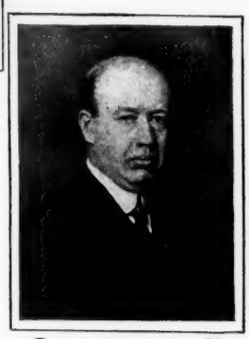


A. G. CHRISTIE
PROFESSOR OF M.E.
JOHNS HOPKINS UNIVERSITY



E. B. KATTE
CHIEF ENGINEER, ELECTRIC TRACTION
N.Y.C.R.R.

I. E. MOULTROP
CHAIRMAN
EDISON ELECTRIC ILLUMINATING CO.
OF BOSTON

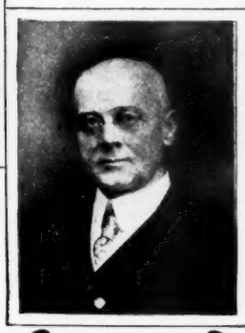


MILAN R. BUMP
PAST PRESIDENT
N.E.L.A.

FRED FELDERMAN
NATIONAL PRESIDENT
N.A.S.E.

DAVID M. MYERS
CONSULTING ENGINEER
GRIGGS & MYERS

FRED W. PAYNE
CO-MANAGER
EXPOSITION



FRED R. LOW
EDITOR
POWER

CHARLES F. ROTH
CO-MANAGER
EXPOSITION

Co., is showing diagrams and models of two stokers brought out during the last year—the Riley "superstoker," described in *Power* for Oct. 3, 1922, and the Jones lateral retort stoker, described in Aug. 1 issue. The "superstoker" is an extra long model, built to replace the two stokers feeding from opposite sides under the large sizes of Stirling boilers. The first installation was made in February, 1922, at the Delray plant of the Detroit Edison Co. In the Jones lateral retort stoker, the coal is pushed through the front wall into a central retort, from which it is distributed into the lateral retorts, the underfeed principle being maintained throughout. This stoker is of the side-cleaning type; in this respect it resembles closely the Jones A. C. stoker.

The Hand Stoker Co., New York City, representing Flynn & Emrich Co., Baltimore, is another company having an exhibit in actual operation. This consists of

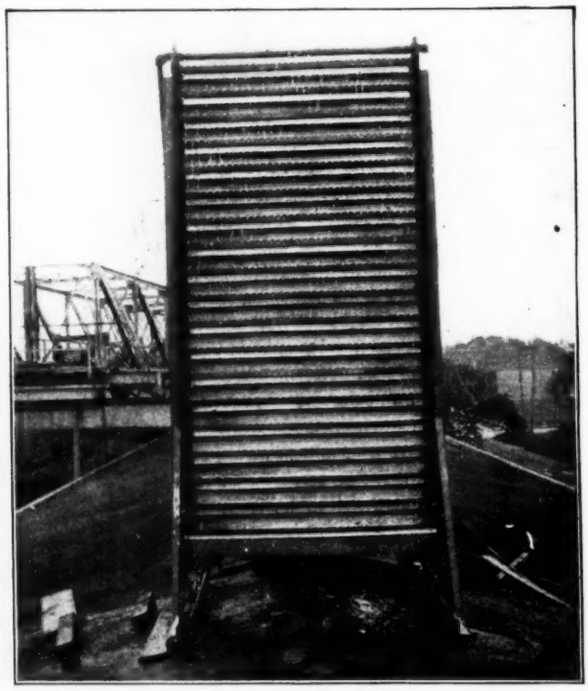


FIG. 1—SMALL COOLING TOWER

a two-section Huber hand stoker equipped with a hopper feed, set up on the floor in operating position with all parts in motion. All accompanying details, such as side walls, bridge wall and ashpit construction are faithfully shown, making it an exhibit of considerable educational value. The company states that this combination of hopper feed and hand stoker provides a means whereby high-volatile bituminous coal may be burned.

For driving mechanical stokers, the London Steam Turbine Co., of Troy, N. Y., is featuring the small turbine described in *Power* for Oct. 10, 1922. This is a simple governor-controlled unit, giving a speed range of the main drive shaft of 100 to 400 r.p.m. Only two ball bearings are used on the turbine shaft, and the gears run in a bath of oil. The turbine rotor is of the single-stage, impulse type, with two rows of blades.

Turning now to fuel oil, we find at the exhibit of the Bethlehem Shipbuilding Corp., Ltd., a complete oil-burning system, including all accessories, such as heaters, pumps, strainers, etc., with the burner and furnace front mounted on a dummy boiler front as in an actual installation. At the Engineer Co.'s exhibit, also, an oil burner—the "Enco," described in *Power* for Nov. 14, 1922—is mounted together with its air shutters in operating position.

Condensers and Auxiliaries

Lately, says the Wheeler Condenser and Engineering Co., there has been greater and greater stress laid upon the necessity for obtaining as small a difference as possible between the temperature of the exhaust steam and that of the condensate in the hot-well of a condenser. At the plant of the El Paso Electric Railway Co., Texas, where a Wheeler 18,000-cu.ft. surface condenser serves a 7,500-kw. turbine, the circulating water being cooled by a combined induced- and natural-draft cooling tower, a difference as small as 2 to 3 deg. F. was obtained between the exhaust-steam temperature and that of the condensate in the hotwell of a conbetween exhaust steam and outlet water was only 7 deg. A steam-jet air pump, consuming 1,000 lb. of steam per hour, was used. The Wheeler exhibit is another in which models are used to show the construction and application of the company's products. One model shows where condensing equipment fits into the power plant, while another is of the Wheeler combined induced- and natural-draft cooling tower. The main feature, however, is the company's latest type of steam-jet air pump.

At the booth of Edwin Burhorn Co., New York City, there will be found a quarter-size working model of the Burhorn "Smaltower." The "Smaltower" is a new type of cooling tower designed especially for small plants where the amount of water required for cooling does not exceed twenty gallons a minute. The company believes that this new tower will be used extensively for cooling the water from gas engines, air compressors, electric transformers, etc. The loss of water, principally due to evaporation, is not over 1½ per cent. The working model shows the water distribution through the tower and also shows the novel louvre system, said to prevent water from flowing out of the tower, even in heavy winds. The "Smaltower" is guaranteed to cool the water from 90 to 80 deg. F., where the air is 80 deg. and the humidity not over 70 per cent, and also to cool water under all similar atmospheric conditions to within five degrees of wet-bulb temperature. One of these towers with a capacity of 5 gal. per min., is shown in Fig. 1.

The Bethlehem Shipbuilding Corporation, Ltd., is exhibiting two types of boiler-feed pumps which, although well known abroad, only recently have been introduced in this country. In the Bethlehem-Weir turbo-feed pump, shown in Fig. 3, a single-stage high-pressure rotary pump is direct-connected to an impulse turbine having one pressure and several velocity stages. Variations in boiler-feed pressure and pump-discharge pressure are controlled by an hydraulic governor. A safety governor shuts off steam when the speed exceeds the maximum for specified operating conditions. The pump shown at the exhibit has a capacity of 8,400 gal. per hour against a discharge pressure of 300 lb. per square inch.

The other new pump is the Bethlehem-Weir reciprocating feed pump. This is a moderate-speed simplex pump making use of a special steam valve of the group type. The action of this valve causes the pump to slow down toward the end of the stroke, permitting the water valves to settle quietly in their seats. Any jar or shock

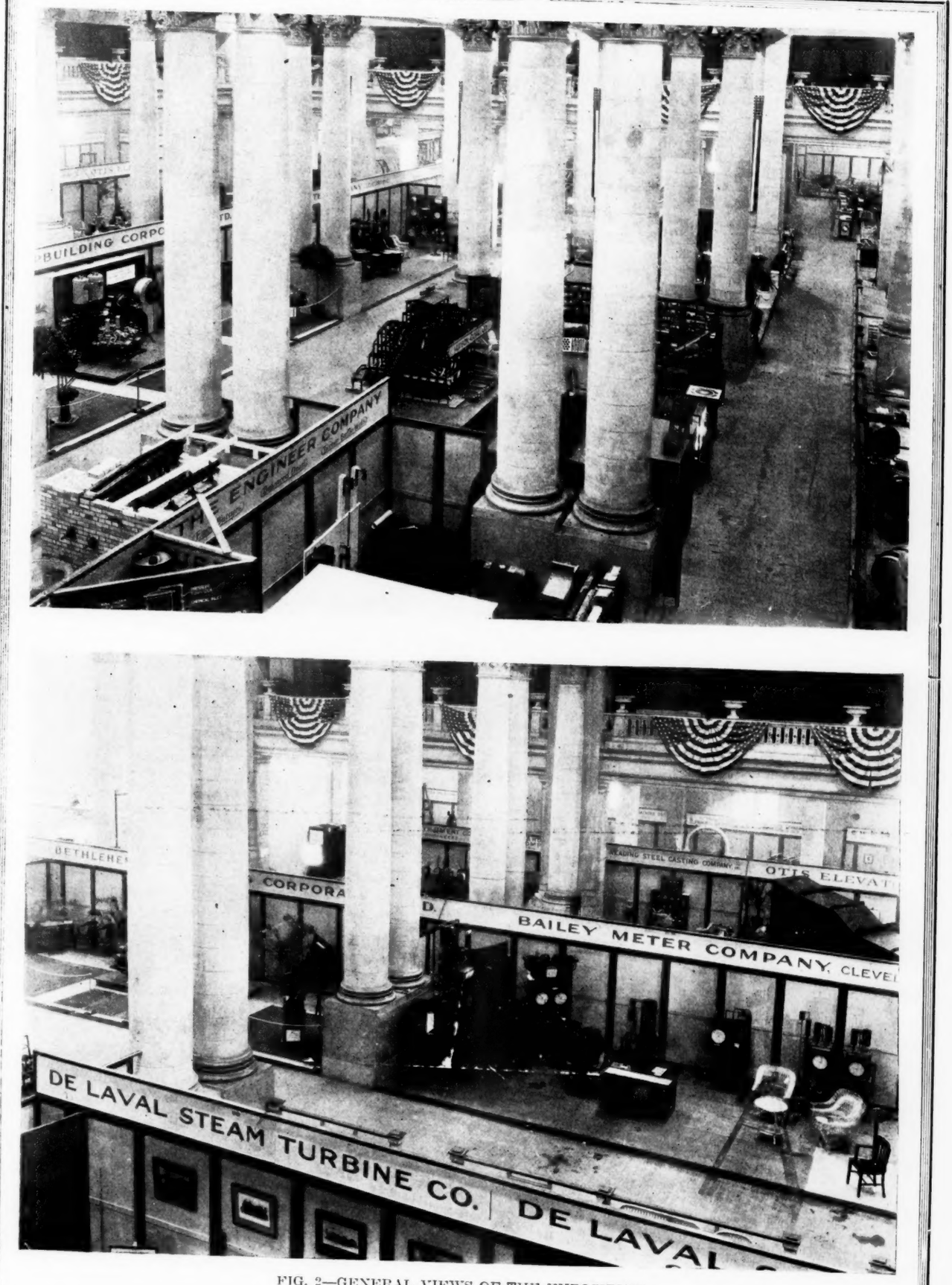


FIG. 2—GENERAL VIEWS OF THE EXPOSITION

in the feed pipes is prevented, as there is no sudden reversal of the piston. A large water-valve area with small lift is obtained by using a number of small valves in a circular seat.

Where pumps driven by motors at slow or moderate speeds must deliver water at pressures higher than are desirable or practicable for a single-stage pump, two separate single-stage pumps are sometimes connected in series instead of using a single-suction multi-stage pump. However, the efficiencies obtained with commercial multi-stage single-suction pumps are not as great as those possible in a single-stage pump with double-suction impellers, according to the De Laval Steam Turbine Co., which is exhibiting a new multi-stage type known as a "series" pump—in effect, two single stage pumps operating in series but built in the same casing. The advantages of the double-suction impeller are retained by the use of a specially formed casing, providing individual volutes for each impeller with ample interconnecting passages within the casing itself. One of these pumps, with casing cover removed, is shown in Fig. 4.

The peculiar feature of this pump is the combination of double-suction impellers and volute diffusers with multi-staging. The high efficiency is attributed to the use of volute diffusers rather than diffusion vanes. As compared with a single suction impeller, the double-

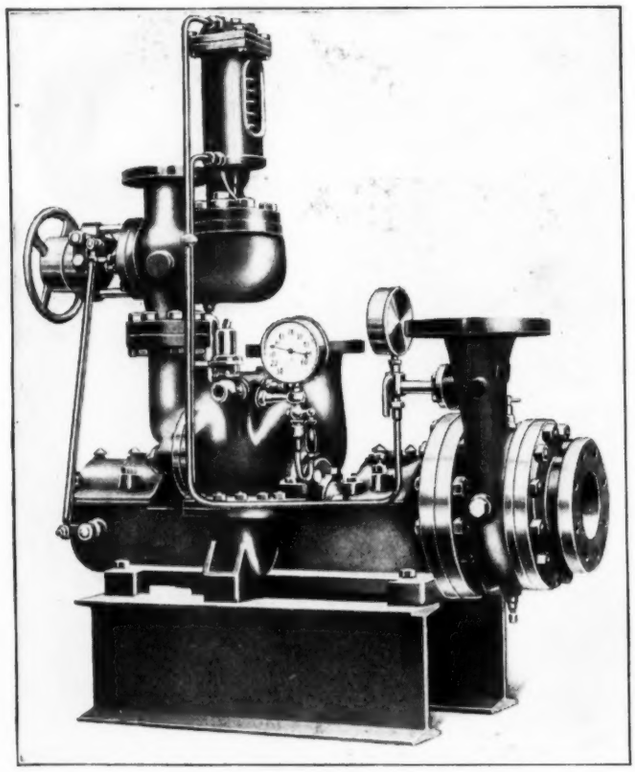


FIG. 3—TURBO FEED PUMP

suction impeller has a smaller suction eye, which permits of making the impeller itself smaller in diameter, and hence the pump can be built to operate at a higher speed for a given head and capacity, or for the same speed, head and capacity a higher efficiency may be obtained.

To meet the present tendency toward higher steam pressures and higher superheat, the De Laval Steam Turbine Co. has redesigned its complete line of velocity stage turbines for auxiliary drive. The steam chest has been placed in the turbine cover away from the bearings, thus reducing the transfer of heat from steam to bearings. In addition, the steam chest and governor valve are now made of steel to withstand the higher steam temperatures.

Feed Water Treatment

The treatment of feed water, to prevent corrosion by removing oxygen and dissolved gases and to remove scale-forming impurities, is now receiving much attention. At the booth of the H. S. B. W.-Cochrane Corp.,

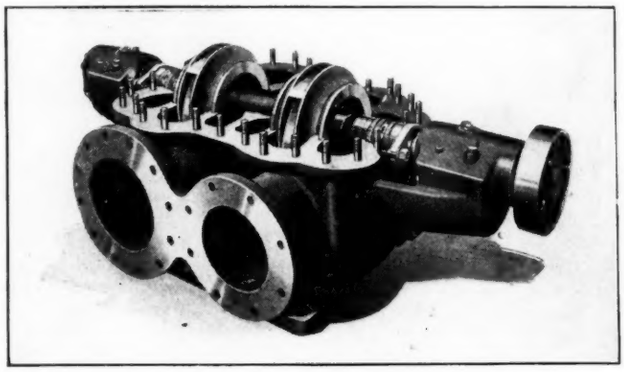


FIG. 4—SERIES CENTRIFUGAL PUMP

an interesting feature in this connection is the Cochrane vacuum deaërator, an open feed-water heater especially designed to remove all dissolved gases during the heating process. In the Cochrane hot-process softener a new feature is the propeller method of agitation used in the chemical tank.

Other exhibitors featuring feed-water treatment are the Griscom-Russell Co., which is showing the Reilly self-scaling high-pressure evaporator; the International Filter Co., showing its hot-flow water softener, and the Dearborn Chemical Co., whose exhibit demonstrates the quantity of mineral solids that would be deposited in a boiler by water of varying degrees and kinds of hardness.

Furnaces, Refractories—Saving Heat

In view of the avowed purpose of the Power Show—the promotion of economy in generating and using power—it is fitting that a large number of the exhibits should be devoted to the means of minimizing the losses due to the heat radiation through furnace walls, boiler shells and steam piping.

The saving of heat through the use of proper insulating materials is being demonstrated at the booth of Keasbey & Mattison Co., where a steam unit is in operation with sections covered by various forms of heat insulation. By means of thermometer readings and charts, the actual savings in B.t.u., tons of coal and dollars and cents are clearly demonstrated.

Tests of refractory materials are being made in small electric furnaces by Quigley Furnace Specialties Co., Inc. Full-size sections of a number of typical furnace walls, to demonstrate the bonding qualities of "Hytempite" for firebrick and granular refractories, will also be found at the Quigley booth. Among these typical furnace walls are some containing monolithic construction and monolithic fill. Methods of patching are being demonstrated on a practical scale.

The Murphy Iron Works is showing its recently de-

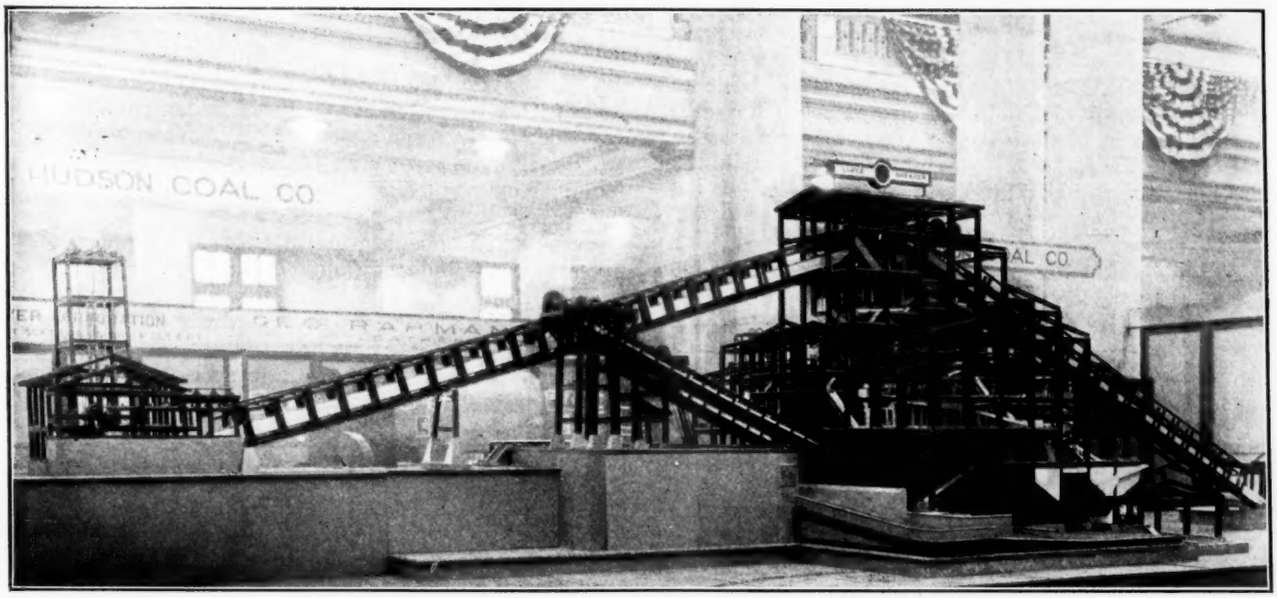


FIG. 5—MODEL OF THE LOREE COAL BREAKER

veloped suspended arch, which consists of a number of slotted blocks, each independently hung from longitudinal pipes, which are in turn supported from transverse I-beams. The arch is cooled by air drawn through the longitudinal pipes by the furnace draft. Every brick in the arch is independently supported and can be removed and replaced without disturbing the others; if desired, this work may be done while the furnace is in operation. The design is said to eliminate all expansion strain, cracking and spalling of brick due to expansion and pressure of adjoining brick.

In addition to its usual line of boiler-setting specialties and refractories, including the large block form of construction for door arches, firebox linings, back arches and blowoff pipe protectors, the McLeod & Henry Co., Troy, N. Y., also is exhibiting a new and improved flat suspended arch for furnaces.

Boiler and Turbine Room Instruments

Among the exhibits devoted to boiler and turbine room instruments, that of the Paul B. Huyette Co., Philadelphia, is of interest in that a Hays CO_2 and draft recorder is shown in operation, so that the action of the instrument may be easily understood.

The Uehling Instrument Co., Paterson, N. J., is also showing its CO_2 recording equipment in operation and is featuring a new method of filtration, making use of what is known as the "Pyroporus" gas filter. This filter is used to completely exclude soot and dirt from the gas sampling line. It consists of two heavy but highly porous disks mounted in a special casting, as shown in Fig. 6. It is inserted in the flue or last pass of the furnace, the disks possessing the necessary refractory qualities to resist the high temperatures. The use of this filter does away with the blowing out of the gas line, so often necessary when cotton waste is used to filter the gas. The disks are easily replaced and are moderate in cost. Another instrument recently introduced by the Uehling company is the combined barometer and vacuum recorder. This instrument records on a single chart both barometric pressure and condenser back pressure. Thus, using the barometer record as a base line, the absolute back pressure may be read directly from the chart. The instrument consists of two float chambers in one casting, one connected with a barometric mercury column, the other with a mercury column in communication with the condenser. These columns and double float chambers are secured to the case of the recorder. The pens are actuated by floats resting on the mercury. The application of the simple mercury column in this instrument is said to make for accuracy and reliability.

A mechanical CO_2 indicator of more than usual interest is being shown by the Olsson Corporation, of New York City. This indicator, called "a gas balance," is entirely mechanical in operation, making use of no chemicals whatever. In fact, as its name indicates, the device is little more than a sensitive beam balance, with a very light, airtight metal float on one arm and compensating weights on the other. Flue gas is heavier than air, by an amount depending on the percentage of CO_2. Therefore, when a sample of flue gas is injected into the box containing the balance, the buoyancy of the air float, in the denser atmosphere of flue gas, causes it to rise. The pointer of the balance then indicates on a suitably calibrated scale the percentage of CO_2 in the gas. The gas is drawn from the flue by a common type of water suction pump, the solubility of CO_2 in water being taken into account when determining the scale of the balance. The instrument is mounted on the boiler front and is said to show the fireman continuously and almost instantaneously the quality of combustion in his furnace.

The Cochrane V-notch recorder, shown in connection with the V-notch meter, is of a new design producing a circular instead of rectangular chart. The H.S.B.W.-Cochrane Corp. is also exhibiting its new flow meter, described in *Power* for Oct. 10. On exhibition for the first time is the Cochrane weighing meter, an ingenious machine for weighing feed water. The liquid is weighed in a tilting bucket, balanced on knife wedges against a counterweight. The bucket is so proportioned that it operates smoothly and silently without striking against a stop. The accuracy is guaranteed to be within one per cent, plus or minus. An instrument never before seen by engineers of this country is the Lea Coal Meter,

exhibited at the Yarnall-Waring booth. This meter is the invention of Mr. James E. Lea, of England, the well-known inventor of the V-notch meter. The dial on the meter gives the rate of flow of coal through the gate of a chain grate stoker. Another interesting feature of the Yarnall-Waring exhibit is the operating full size model of the Yarway-Lea V-notch meter.

Specialties and Accessories

At the booth of the Walworth Mfg. Co. will be found a very complete exhibit of the company's products, including feed water heaters and regulators, thermostats, pump governors, balanced float valves, gate and globe valves, tools, etc. A small gas-fired steam boiler is used to generate the amount of steam needed to operate the Watts line of regulating valves and automatic damper regulators. The Stack gas water heater and indirect heater are also shown in operation.

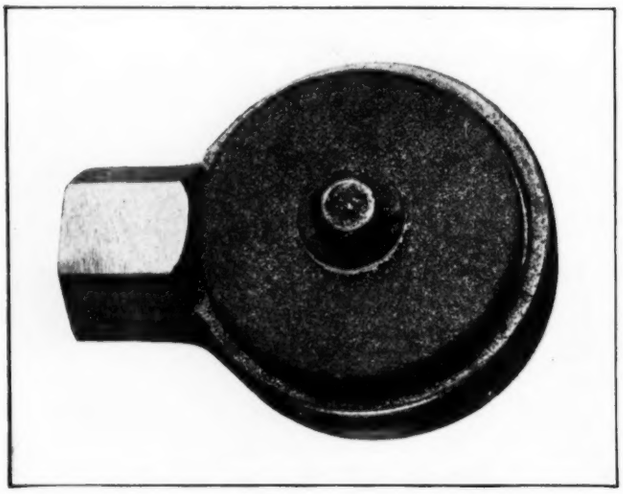


FIG. 6—"PYRO-PORUS" GAS FILTER

An application of the well-known centrifugal principle to the purification of oils is found in the De Laval oil purifier, exhibited by the De Laval Separator Co. A portable model of the No. 600 De Laval transformer oil purifier is shown in operation. It is stated that in many of the smaller power plants this purifier is used for either transformer or lubricating oil, thus making one unit do the work of two.

The exhibit of the Scovill Manufacturing Co. is notable both for its beauty and for its instructive features. The molecular structure of Muntz and Admiralty metals, from which condenser tubes are made, is demonstrated to the visitor by a number of conveniently arranged microscopes with polished and etched specimens mounted beneath them.

The Otis Elevator Co. is showing a complete Otis gearless traction multi-stage micro-drive machine with magnet controllers. There is also being shown a balancer set with a capacity for several elevators, a car-operating switch, micro-leveling switch, stopping switch, speed governor and car safety devices. The entire exhibit is in operation, showing the functions of the various elevator parts.

The "S-C" receiver drainage control, exhibited by the "S-C" Regulator Manufacturing Co., Fostoria, Ohio, and described in *Power* for Aug. 8, 1922, is one of the recently introduced boiler accessories.

Among the devices for controlling combustion is the Northwestern boiler damper control, exhibited by Stewart-Sayers Co., and described in *Power* for Aug. 22, 1922. This regulator may be used to control automatically damper position, stoker speed, or both of these functions simultaneously. It is sensitive in operation, being affected by draft pressure changes as small as 0.01 in. water column.

Recognizing the general trend toward higher steam pressures, the Reliance Gauge Column Co. is exhibiting its forged steel water column, now built for pressures up to 500 lb. which is as high a pressure as the company has had any call for. This pressure necessitates the use of special floats of a new metal, a special whistle valve of new design, and extra heavy water gage glass and gage cocks.

Transmission Equipment

Tests of the several different types of leather and fabric belting are being made at the exhibit of the Leather Belting Exchange. The testing apparatus consists of a motor driving through a belt to a dynamometer, on which is indicated the horsepower transmitted and the slippage. The speed and belt tension are also recorded. A similar but larger piece of apparatus has been used for some time by the Leather Belting Exchange Foundation to determine the comparative values of the different kinds of belting. This apparatus, first installed at the Mellon Institute of Industrial Research at Pittsburgh, is now located at the Sibley College of Engineering, Cornell University. Tests have been made of the best grades of leather belting, solid woven cotton belting, Balata and friction surface rubber belting.

A running exhibit of a combined vertical pump thrust and steady bearing will be found at the Kingsbury Machine Works booth. There is also exhibited one shoe for the world's largest thrust bearing, now being built for an extension of Hydraulic Plant No. 3 of the Niagara Falls Hydro-Electric Co. The equality of load distribution on a six-shoe thrust bearing is being demonstrated. In addition, the principle of the air-lubricated thrust bearing is made apparent in a model in which an electric current will not pass from one-half of the bearing to the other, thus showing the presence of the air film.

Two new types of couplings are shown at the Smith & Serrell booth. The "Fractional H.P." type of "Francke" flexible coupling is being made in small inexpensive sizes for small motor-driven generators and centrifugal pumps and for magneto and pump drives, while the high-speed type has been developed primarily for high-speed motors and turbine-driven herringbone gear units.

A new pressed-steel countershaft, complete with hangers and shafting and equipped with a No. 6 double Johnson friction clutch is being shown in operation by the Carlyle-Johnson Machine Co. The company is also demonstrating the method of incorporating the various self-lubricating bearings in the clutch hub for high-speed work.

Coal- and Ash-Handling Equipment

One of the exhibitors of coal and ash-handling equipment is Gillis & Geoghegan, New York City, who are showing their entire line of ash-removal equipment, consisting of four types with two electrically driven models. Of particular interest is the new model E,

which raises cans electrically from boiler room to grade level and lowers the empties by gravity. The hoisting speed is about 60 ft. per min., and the empty cans may be dropped under the control of a powerful brake as fast as one may drop a stone.

Instead of the use of interior coal bunkers, requiring complex conveying machinery and often obstructing light and ventilation, the R. H. Beaumont Co. is advocating the idea of building the coal bunker at one end of the boiler house and hoisting coal to it by cable-pulled buckets. A neat little model at the Beaumont exhibit shows the coal being drawn to the skip hoist from the coal pile by a miniature drag scraper, power-operated and correct in every detail. The coal is then hoisted to the bunker, from which it is distributed to the boilers by a weigh larry, also reproduced with faithful attention to detail. The company recommends building the bunker exterior to the boiler house because of the reduced cost and elimination of complicated conveying machinery made possible by this arrangement.

At the booth of the Victor Engineering Co. is seen a section of their steam jet ash conveyor, with such special features as interchangeable liners, liner keys and a renewable plate in the section above the elbow where erosion from the rebound of the jet is liable to occur.

Piping, Valves and Fittings

Nearly every exhibit of valves and fittings gives evidence of the present tendency toward higher pressures and temperatures. In the last N.E.L.A. "Report of Prime Movers Committee," the majority of the manufacturers of piping, valves and fittings stated that they were prepared to handle pressures of 350 to 500 lb. and temperatures of 700 to 800 deg. F. Cast steel and monel metal construction is almost universal in high-pressure valves.

At the Lunkenheimer Co.'s booth, two motor-controlled valves equipped with the Deane system of control are displayed. One of these is a 12-in. cast steel monel-mounted gate valve, similar to the valve which made such a commendable showing on the Essex tests. The other is an 8-in. electrically operated reducing valve, designed to maintain constant conditions in a plant generating steam at two different pressures. This system will be of interest to engineers facing the problem of adding boiler capacity to an existing plant operating at a pressure less than that at which it is desired to run the new boilers. A complete line of cast steel, monel-mounted valves for operating conditions of 350 lb. and 800 deg. F. is being shown.

Valves of monel metal for high pressure and temperature work are also featured at the booth of the Hancock Inspirator Co., sales department of Manning, Maxwell & Moore, Inc. The newest development is the Hancock cone seat and disk valve, made in all sizes from $\frac{3}{8}$ in. to $2\frac{1}{2}$ in. inclusive.

The Reading Steel Casting Co., also, is featuring a motor-controlled valve in actual operation—the new design of Reading extra heavy cast steel gate valve, equipped with E-1 Deane control for motor operation. As a new number in the Pratt & Cady line, the Reading company is showing a bronze asbestos disk globe valve, with a union bonnet.

In addition to its regular line the Yarnall-Waring Co. is showing a disassembled model of its new 1-in. Yarway-Junior seatless valve, used for steam turbine drips.

A system of remote control has been incorporated with the Cochrane Multiport safety exhaust outlet or back pressure valve, exhibited at the booth of the H.S.B.W.-Cochrane Corp. This remote control is for use in installations where the valve is placed, say, at the tenth floor and is to be operated from the engine room in the basement by means of an electric motor. Merely by throwing a switch, the engineer may increase or decrease the back pressure.

A highly interesting valve is that shown by the Kelly Valve Co.—the Kelly Self-Grinding Valve, a metal-to-metal seat valve that grinds itself each time it is closed. When the handle is turned, the disk does not come to a rigid stop the moment it touches the seat, as in the standard type. Instead, it makes a complete revolution on the seat while held there by the pressure of a heavy spring. The lime accumulation (so destructive in ordinary valves) acts as a grinding agent. All unevenness in the disk and seating surface is eliminated before it has developed to a point where it can cause even the slightest leak. The valve may be packed without interrupting service—a time saving feature—and is made for water, gas, oil, steam, ammonia and oil.

EXHIBITORS AT THE POWER SHOW AND THEIR PRODUCTS

STOKERS, PULVERIZED FUEL AND OIL-BURNING EQUIPMENT

Manufacturer	Product
Bethlehem Shipbuilding Corp., Ltd., Bethlehem, Pa.	Bethlehem (Dahl) oil burning system
The Engineer Co., New York City	"Enco" oil burners
Flynn & Emrich Co., Baltimore, Md.	
Gibby Engineering Co., East Boston, Mass	Files hand stoker
Hand Stoker Co., New York City	Huber hand stoker, Huber hopper feed
International Combustion Engineering Corp., New York City	Frederick, type E, Coxe, hand stokers; Grieve grates; air heaters; Green natural and forced draft chain grates; Lopulco powdered coal system
Pyramid Iron Products Co., New York City	Pyramid grates
Sanford Riley Stoker Co., Worcester, Mass.	Riley "super-stoker," Jones lateral retort stoker

CONDENSERS AND POWER STATION AUXILIARIES

Bethlehem Shipbuilding Corp., Ltd. Bethlehem, Pa.	Bethlehem-Weir turbo-feed pump; Bethlehem-Weir reciprocating feed pump
Bishop & Babcock, Cleveland, Ohio	Vacuum pumps
Burhorn, Edwin W. Co., New York City	Cooling towers
Carling Turbine Blower Co., Worcester, Mass	Turbine blowers
(Vincent-Gilson Engineering Co., New York City)	
Coppus Engineering & Equipment Co., Worcester, Mass.	Undergrate blowers, "Vano" and centrifugal blowers, feed pump steam turbines
Davidson, M. T. Co., New York City	Davidson steam pumps
De Laval Steam Turbine Co., Trenton, N. J.	Auxiliary steam turbines, two-stage centrifugal pumps
Foster Engineering Co., Newark, N. J.	Automatic valve specialties
Frederick Iron & Steel Co., Frederick, Md.	Centrifugal pumps, rotary "Spirex" vacuum pump
London Steam Turbine Co., Troy, N. Y.	Governor-controlled turbine for stoker drive
Midwest Engine & Supply Co., New York City	Air filters, steel sections for machinery supports
Nash Engineering Co., South Norwalk, Conn.	Compressors, pumps
Seovill Mfg. Co., Waterbury, Conn.	Brass, bronze and nickel silver; condenser tubing
U. S. Cast Iron Pipe & Foundry Co., Burlington, N. J.	Barometric condensers
C. H. Wheeler Mfg. Co., Philadelphia, Pa.	Condensers, cooling towers, pumps, engines
Wheeler Condenser & Engineering Co., Carteret, N. J.	Condensers, evaporators, cooling towers, feed water heaters, steam jet air pumps

BOILERS, SUPERHEATERS AND ECONOMIZERS

Geo. T. Ladd Co., Pittsburgh, Pa.	Water tube boilers
Power Specialty Co., New York City	Foster superheaters and economizers
Superheater Co., New York City	"Elesco" superheater and atmospheric ammonia condenser coil
D. Connelly Boiler Co., Cleveland, Ohio	Connelly water-tube boilers

EXHIBITORS AT THE POWER SHOW AND THEIR PRODUCTS (Continued)

FEED-WATER TREATMENT

Manufacturer	Product
H. S. B. W.-Cochrane Corp., Philadelphia, Pa.	Deaerating heaters, hot process softeners
Griscom-Russell Co., New York City	Reilly evaporators
Graver Corp., East Chicago, Ind.	Hot process softeners
Dearborn Chemical Co., Chicago and New York City	Feed water treatment, "No-Ox-Id" rust preventative
International Filter Co., Chicago, Ill.	Water softeners and filters, "International Hot-Flow" water softener

FURNACES, ARCHES, REFRACTORIES AND HEAT INSULATION

American Arch Co., New York City	Type P furnace arch
Bernitz Furnace Appliance Co., Boston, Mass.	Clinker-proof furnace walls, blocks, brick and special tile
Celite Products Co., Chicago, Ill.	"Sil-O-Cel" insulating brick, block, powder and cements. "Fraxite" high temperature cements
M. H. Detrick Co., Chicago, Ill.	Flat suspended fire tile arches
Drake Non-Clinkering Furnace Block Co., New York City	Non-clinkering furnace blocks
The Engineer Co., New York City (Vincent-Gilson Engineering Co.	Turner baffle walls
International Combustion Engineering Corp., New York City	Green furnace arches
Keasbey & Mattison Co., Ambler, Pa.	"85 per cent" magnesia covering
King Refractories Co., Buffalo, N. Y.	"Mono" boiler baffling "Flame" brand high temperature cements
Liptak Firebrick Arch Co., Minneapolis, Minn.	Furnace arches
McLeod & Henry, Troy, N. Y.	Large block construction for door arches, firebox linings, flat suspended arches
Quigley Furnace Specialties Co., New York City	"Hytempite," for bonding firebrick; "Carbosand," for furnace lining and patching; "Insulbrix," high temperature insulation

COAL- AND ASH-HANDLING SYSTEMS

Allen-Sherman-Hoff Co., Philadelphia, Pa.	"A-S-H" hoppers and gates
R. H. Beaumont Co., Philadelphia, Pa.	Coal, coke and ash handling systems; skip hoists, coal weigh larries, drag scrapers, bunker construction
M. H. Detrick Co., Chicago, Ill.	Steam jet ash conveyors
Frederick Iron & Steel Co., Frederick, Md.	Ash conveyors
Gillis-Geoghegan, Inc., New York City	Telescopic hoists for ash removal
International Combustion Engineering Corp., New York City	Green ash tanks
C. W. Hunt Co., Inc., Staten Island, N. Y.	Pivoted bucket conveyors, skip hoists, coal crackers, weighing larries and hoppers.

BOILER AND TURBINE ROOM INSTRUMENTS

Ashton Valve Co., Cambridge, Mass.	Gages, gage testers, master pilot gages
Bailey Meter Co., Cleveland, Ohio	Meters for steam, water, coal, air, gas; ash pit loss recorders, multipointer gages
H. S. B. W.-Cochrane Corp., Philadelphia, Pa.	Flow meters, V-notch meters, weighing meters
Foxboro Co., Foxboro, Mass.	Indicating and recording gages and thermometers, CO_2 recorders
Paul B. Huyette Co., Philadelphia, Pa. (Jos. W. Hays Corp.)	Hays CO_2 and draft recorder, draft gages and gas analyzers, P.B.H water gage
Republic Flow Meters Co., Chicago, Ill.	Meters for steam, water, air and gas; CO_2 recorders; Republic system of power-plant cost accounting
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y. (American Steam Gage and Valve Co., Boston, Mass.)	Indicating and recording gages and thermometers; tachometers
C. J. Tagliabue Mfg. Co., Brooklyn, N. Y	"Tag" automatic controllers for temperature pressure time, etc., "Tag-Mono" gas analysis recorder; thermometers, indicating and recording
Uehling Instrument Co., Paterson, N. J.	Combined barometer and vacuum recorder; CO_2 recording equipment "Pyro-porus" gas filter
Yarnall-Waring Co., Philadelphia, Pa.	"Yarway-Lea" V-notch meter
Ellison, Lewis M., Chicago, Ill.	Inclined and vertical draft gages
Lunkenheimer Co., Cincinnati, Ohio.	Water columns and gages, low water alarms
Olsson Corp., New York City	"Gas balance" CO_2 recorder

VALVES, PIPING AND FITTINGS

Ashton Valve Co., Cambridge, Mass.	Pop safety valves
Baig & Hill, New York City	Steam fitters supplies
S. F. Bowser & Co., Inc., Fort Wayne, Ind.	"Nokut" pump valves, brass and steel valves
A. W. Cash Co., Decatur, Ill.	Pressure reducing and regulating valves, expansion and relief valves
H. S. B. W.-Cochrane Corp., Philadelphia, Pa.	Multiport back pressure valves and drainers
Crane Company, Chicago, Ill.	Valve fittings and specialties
Edward Valve & Mfg. Co., East Chicago, Indiana	Valves, fittings and specialties
Foster Engineering Co., Newark, N. J.	Automatic Valve specialties
Jenkins Bros., New York City	Regrinding marine valves, rapid action valves, standard valves
Kelly Valve Co., Muskegon, Mich.	Self-grinding valves
Kieley & Mueller, Inc., New York City	Relief, reducing and back pressure valves
Lead-Lined Iron Pipe Co., Wakefield, Mass.	Fittings and valves
Lunkenheimer Co., Cincinnati, Ohio.	Motor-controlled valves; standard valves and fittings, reducing valves
Manning, Maxwell & Moore, Inc., New York City (Hancock Inspirator Co.)	Hancock valves, Ashcroft gages
Pittsburgh Valve Foundry & Const. Co., Pittsburgh, Pa.	Standard valves and fittings, motor-operated gate valves
Reading Steel Casting Co. (Pratt & Cady division), Reading, Pa.	Extra heavy, motor-controlled, cast steal gate valve; Pratt & Cady standard valves and fittings
Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y. (American Steam Gage & Valve Co.)	Pop safety and release valves
U. S. Cast Iron Pipe & Foundry Co., Burlington, N. J.	Pipe and fittings
Walworth Mfg. Co., Boston, Mass.	Standard valves; Watts regulating valves
C. H. Wheeler Mfg. Co., Philadelphia, Pa.	Exhaust gate valves
Yarnall-Waring Co., Philadelphia, Pa.	Seatless and tandem blow-off valve standard line of valves

TRANSMISSION EQUIPMENT

Carlyle-Johnson Machine Co., Manchester, Conn.	Friction clutches, pulleys, shafting hangers
Hill Clutch Co., Cleveland, Ohio	Hill collar oiling bearings, friction clutches, rope drives, hangers, shafting, etc.
Kingsbury Machine Works, Philadelphia, Pa.	Thrust bearings for steam and hydraulic turbines, air-lubricated, self-oiling
Leather Belting Exchange, Philadelphia, Pa.	Belt-testing apparatus
Leddell Metals Co., Long Island City, New York	Babbitt and anti-friction bearing metals
Geo. Rahmann & Co., New York City	Leather belting
Smith & Serrell, Newark, N. J.	"Francke" flexible couplings; "Pintite" rigid couplings; "Keytite" self-fitting keys

SPECIALTIES, ACCESSORIES AND MISCELLANEOUS PRODUCTS

Baker, R. & L., New York Corp., New York City	Baker "Hy-Lift" truck
S. F. Bowser & Co., Inc., Fort Wayne, Ind.	Lubricators, oil purifying systems
Connery & Co., Inc., Philadelphia	Steel Plate work
Dearborn Chemical Co., Chicago, Ill.	Powdered cleaning preparations, hydraulic elevator compound, lubricating oils and greases
De Laval Separator Co., New York City	Centrifugal oil purifiers
Julian d'Este Co., Boston, Mass.	Curtis and d'Este damper regulators and reducing valves; Type G steam regulator
Diamond Power Specialty Co., Detroit, Mich. (Vincent-Gilson Engineering Co., New York City)	Diamond "Valv-in-Head" soot blower
Andrews-Bradshaw Co. (Vincent-Gilson Engineering Co)	Tracy steam purifier
The Engineer Co., New York City (Vincent-Gilson Engineering Co.)	Balanced draft furnace pressure regulator
Foster Engineering Co., Newark, N. J.	Pressure regulators, pump governors
Griscom-Russell Co., New York City	Reilly fuel oil heaters, G-R instantaneous heaters, multiwhirl oil coolers, multi-screen filters, expansion joints, strainers, new Stratton steam, oil and air separators, Bundy oil separator
Hudson Coal Co., Scranton, Pa.	Model of Loree coal breaker, cross-section of mine
Burt Harris, New York City	G & B mineral oil paint
Kieley & Mueller, New York City	Kieley steam traps, "Climax" damper regulators, pump governors
Otis Elevator Co.	Otis gearless traction multi-voltage micro-drive machine with manget controller
Pittsburgh Testing Laboratory, Pittsburgh, Pa.	Inspecting and testing apparatus special machine for compression tests of cement mortars
Racine Machine Tool Co., Racine, Wis.	Machine tools
Reliance Gage Column Co., Cleveland, Ohio	Forged steel water columns
Ruggles-Klingeman Mfg. Co., Salem, Mass.	R-K step-compensated draft or fan engine regulators, temperature regulators
"S-C" Regulator Mfg. Co., Fostoria, Ohio	Pump governors, "S-C" receiver drainage control
Stewart-Sayers Co., New York City	"Northwestern" boiler damper control
Templeton Mfg. Co., Hyde Park, Mass.	"Sterling" steam traps
Tide Water Oil Sales Corp., New York City	Motion pictures, "The Story of Tide Water Oil"
U. S. Cast Iron Pipe & Foundry Co., Burlington, N. J.	Gas producers
Smith Gas Engineering Co., (Vincent-Gilson Engineering Co., New York City)	Gas producers
Vibration Specialty Co., Philadelphia, Pa.	Balancing machines, vibration elimination
Walworth Mfg. Co., Boston, Mass.	Watts feed water damper and pressure regulators, pump governors
Paul B. Huyette Co., Philadelphia, Pa.	"A-Jacks" damper regulator
Yarnall-Waring Co., Philadelphia, Pa.	"Yarway-Richard" discharge and suction unloaders
Coppus Engineering & Equipment Co., Worcester, Mass.	Small electric drive "Vano" blowers for domestic heating.

How To Ground Motor Frames

By EDGAR P. SLACK
Assistant Engineer, Underwriters Laboratories

THE size of ground wire for motor frames compared with those for conduits—Various constructions used in making the connection at the motor frame.

THE rules of the National Electrical Code specifying how motor frames shall be grounded, in cases where such grounding is required, are in most respects the same as the rules for grounding conduits and other metal raceways, as discussed in a recent article.

Two features may be noted, however, in which the grounds for motor frames differ from grounds for raceways. The first is a slightly different regulation for the size of the ground wire, and the second is a difference in the practical method of connecting the ground wire to the apparatus to be protected.

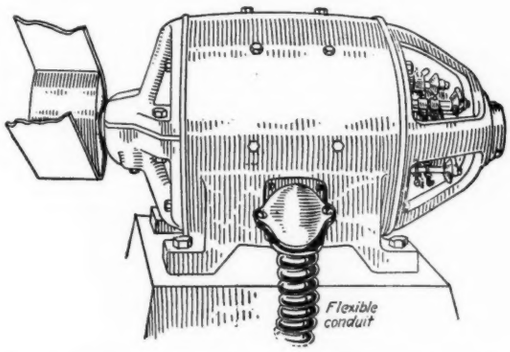


FIG. 1—FLEXIBLE CONDUIT CONNECTED DIRECTLY TO MOTOR FRAME

The size of wire to use for grounding motor frames is determined by the size of the nearest cutout protecting the equipment, as indicated in the following table, which shows also the proper size of lug for the ground wire:

Capacity of Nearest Cutout Protecting the Equipment, in Amperes	Minimum Size of Ground Conductor B. & S. Gage No.	Solder Lug, Minimum Diameter of Hole—Inches
0–100	10	3/16
101–200	6	1/4
201–500	4	3/8
501 and above	2	3/8

Although a comparison of this rule with the corresponding rule for the size of ground wire for conduits or other raceways shows some differences, it will be found in a large majority of practical cases that the same size ground wire is suitable for the frame of the motor as well as for the conduit through which the motor is supplied; or else that the raceway ground is larger than required for the motor frame.

Take the case of a 10-hp. 230-volt compound direct-current motor rated 40 amperes. Such a machine would generally be wired on a branch circuit having a capacity of 125 per cent of 40 or $1.25 \times 40 = 50$ amperes. A No. 6 B. & S. circuit wire would therefore be used and the equipment would be protected by 50-ampere fuses. The proper size of wire for the conduit (since the largest wire contained is smaller than No. 0 B. & S. gage) will be No. 10 B. & S. gage. Also, the proper size of ground wire for the motor frame (since the cutout protecting the equipment is below 100 amperes) is No. 10 B. & S., the same as for the conduit.

If a number of cases selected at random are worked out, it will be seen that almost always the conduit ground is the same size as the motor-frame ground wire, or larger. It is, therefore, common practice, where a motor is wired in conduit or armored cable, to connect the metal of the raceway to the motor frame and make the raceway ground serve to ground the frame as well. Where this is done, the size of ground wire required for the raceway and for the motor frame should be computed separately, and if different, the larger size should be taken for the common ground.

In a good many cases the conduit or armored cable supplying a motor is made up direct to a conduit box or to a cast hood on the motor frame, as in Fig. 1. This is an ideal arrangement on account of the mechanical protection of the wiring and also because it avoids the necessity of an additional ground connection.

Fig. 2 shows a case where the conduit is not attached to the motor frame, the two being bonded together by a copper strap or wire of the specified size, connected to the motor frame and to a ground clamp on the conduit.

To ground the frame of a motor which is not wired in conduit or other metal raceway, it is necessary to run a separate wire to ground, Fig. 3, following the precautions required for raceway grounds as previously described.

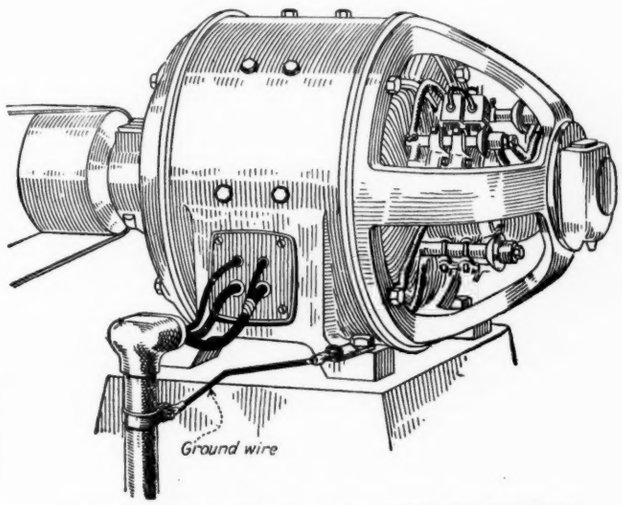


FIG. 2—MOTOR FRAME GROUNDED TO CONDUIT

No standard provision is made for connecting the ground wire to the motor frame, and this connection is usually made up to suit the special conditions of each job. Generally, a heavy copper strap is used, having a large hole at one end which will fit over one of the foundation bolts or some other stud on the machine frame, and which carries at the other end a standard

lug into which the ground wire is sweated. This construction is shown in Fig. 3. It is sometimes possible to attach the lug direct to the frame on a small stud or by means of a bolt threading into a hole tapped in the frame; and it would appear to be a logical development for motor manufacturers to provide a tapped

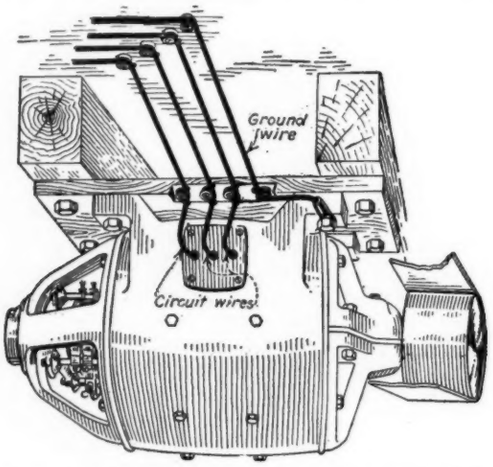


FIG. 3—SEPARATE GROUND WIRE RUN FOR MOTOR FRAME

hole to take a standard bolt for this purpose, preferably near the terminal block.

It frequently happens that a motor is mounted on an I-beam support or on the metal frame of a lathe, printing press, or the like. In these cases it may be easier and is equally acceptable to make the ground connection to the supporting frame instead of the motor frame. Such a case is shown in Fig. 4.

The following features require special attention in making the ground connection at the frame: The point

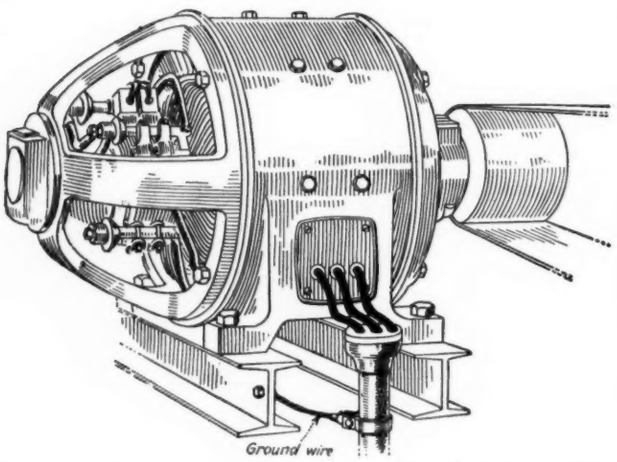


FIG. 4—MOTOR AND CONDUIT GROUNDED TO SUPPORTING STRUCTURE

of attachment should be such that both the connection and the ground wire are protected from injury and still are readily accessible for inspection; paint should be scraped off to insure good electrical contact; the copper strap, if used, should be of at least as large cross-section as the ground wire, to prevent possible burnout; and the entire installation should be strong and substantial. In other respects the same precautions should be used in grounding motor frames that are taken in grounding conduits.

Lubrication of Wire Ropes

By Charles A. Armstrong

Contrary to the general idea a wire rope is a complex mechanism, composed of a number of wires twisted to form a strand, and then a number of these strands are twisted about a hemp center to form the rope. The combinations of number of wires per strand and the number of strands in a rope are practically unlimited. There are on the market about seventy of these combinations, but for elevator service 6 strands of 19 wires each has become the type that is generally used.

A very large percentage of the ropes used on elevators today are made of carbon steel, or as it is sometimes called, plow steel. Wire ropes can be made from this material that will test up to 280,000 lb. per sq.in.

In elevator service the cables bend over sheaves, and while the car is in motion parts of the cable are continuously bending and straightening out again. This operation causes a continuous rubbing of the wires and strands upon each other. These rubbing surfaces, like any other, require lubrication. When the rope is made, the hemp center is thoroughly saturated with lubrication and if not installed in a damp place this will furnish sufficient lubrication for the cable for a considerable period.

There is considerable difference of opinion with regard to the application of external lubrication, but it has been proved by tests that internal friction in the cable increases bending stresses that cause wires to break. This fact alone should be sufficient to warrant lubrication of elevator cables. Where the wires on the outside break, they can be seen and detected before the cable gets in a dangerous condition. However, when the inside wires break, as they sometimes do owing to lack of lubrication, the rope may reach the danger point without giving external evidence. Ropes operating in vapor, fumes or in damp places will rust and corrode unless they are kept lubricated.

There seems to be little reason for not lubricating elevator cables when the advantages are weighed against the objections. About the most serious objection is that of the extra work and the care that must be exercised to prevent the lubricant dropping into the car. A good non-acid, medium-heavy oil that will penetrate to the core and also stick to the surface is desirable. There is not much value in a lubricant that is so thin that it will run easily and drip from the rope. On the other hand, it should not be so thick and sticky that it will not penetrate into the hemp center. A number of elevator manufacturers have for sale lubricants that they recommend for this purpose. Experiments have proved that a non-acid lubricant having a Saybolt viscosity of from 1,000 to 2,000 sec. at 210 deg. is well suited for this purpose.

Some authorities claim that where the cables are in a warm, dry place and in use less than three years and run over generous-sized drums and sheaves, there is sufficient lubrication in the cable to prevent abrasion of the wires and strands on each other. If the life of the cables exceeds this period or when they travel over small sheaves or drums, frequent lubrication is necessary, particularly in cold, damp places. The best practice will be found to watch the cables carefully and to apply lubrication if they show signs of being dry or rusting. Even in dry places it will be found good practice to apply lubrication at least once every six months and every three months under the more severe conditions.

Using Tar Oil in Solid Injection Engines

By H. F. Shepherd

An interesting development is the Crossley Cold Starting Airless Injection Engine fitted for burning tar oils. The builders are quite frank in their treatment of the subject. Confirming the experience of our own American engineers, they state in effect that a low-grade tar oil may appear to be cheap, but in fact prove to be a very expensive fuel owing to impurities. More frequent cleaning, excessive expense for lubrication and increased repairs are the results of a bad product.

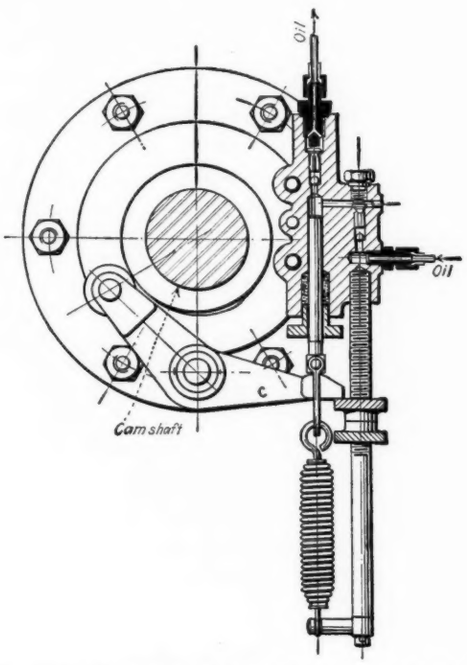


FIG. 1—ARRANGEMENT OF FUEL PUMP AND CAM

As is usual with Diesel engines, the Crossley engine injects a "pilot charge" of petroleum oil ahead of the tar-oil charge to insure ignition of the latter. This is not always required, for although pit-coal tar oil (creosote), carburetted water-gas tar (creosote) and blast-furnace tar (creosote) require an ignition charge, lignite tar oil does not. It has been found that petroleum residuum from California and Mexico crudes may use an ignition charge to advantage.

As a guide in purchasing such byproducts, Crossley recommends the following specifications:

Character of Oil	Specific Gravity
Pit-coal tar oil	1.00 to 1.07
Carb. water-gas tar	0.98 to 1.06
Blast-furnace tar	0.96 to 1.06
Lignite tar	not over 0.92

Flash—Not under 50 deg. C. (122 deg. F.), closed cup test. Distillation—not less than 60 per cent to distill over at 300 deg. C.

Mechanical Impurities	
Insoluble in benzine	not over 0.5 per cent
Ash, hard ash	not over 0.05 per cent
Ash, soft ash	not over 0.08 per cent
Coke	not over 3 per cent
Water	not over 2 per cent

The whole of the oil must remain liquid at 60 deg. F.

It is not only necessary to good and economical operation to use ignition oil with most tar oils, but it is sometimes dangerous to operate without it. The tar oil, when used alone, has a tendency to misfire and accumulate, firing as a "layover" after several missed cycles, with heavy premature explosion.

The Crossley "pilot gear," through which the ignition oil is admitted ahead of the tar-oil charge, is very simple. Fig. 1 shows the ignition oil pump driven from the layshaft. The stroke of the pump plunger is adjustable, being regulated by the lift of the cam lever *C* on the suction stroke. This is controlled by an adjustable nut as shown. Adjustment of the amount of ignition oil is made to suit the tar oil in use, and this is held constant at all loads. The governor varies the tar-oil pump (main fuel pump) delivery, to suit the load; the ratio of ignition oil to tar oil then increases automatically as the load lightens.

TEST ON CROSSLEY OIL ENGINE

Hp. of engine	117
Cylinder diameter, in.	18½
Piston stroke, in.	28
Speed, r.p.m.	180
Fuel consumption per b.hp.-hr.	
At 146 b.hp. lb. per b.hp.	0.514
129 b.hp. lb. per b.hp.	0.504
102 b.hp. lb. per b.hp.	0.475
67 b.hp. lb. per b.hp.	0.488
32 b.hp. lb. per b.hp.	0.700

These figures include a small proportion of kerosene used for ignition purposes

The standard or petroleum oil sprayer is shown in Fig. 2*A*. The needle valve *B* is lifted automatically by the fuel-pump pressure, admitting the fuel to the combustion chamber through the drilled tip, which atomizes it.

As fitted for tar oil, a separate passage, Fig. 2 *B*, conducts the ignition oil to the annular ring *a* in the tar-oil sleeve at the tip of the sprayer. The ignition oil is then introduced to the combustion chamber and ignited first, thereby providing a proper atmosphere for the reception of the tar oil.

The engine is preferably started on light refined oil and is operated on this oil for a short time before stopping to fill the pump and sprayer with petroleum oil for the next start.

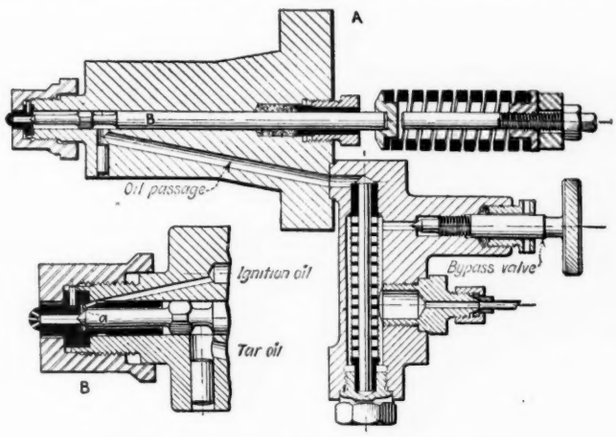


FIG. 2—DESIGNS OF SPRAY NOZZLES
A—Standard type. *B*—Nozzle fitted for tar oil.

Jackets must be maintained at not less than 100 to 120 deg. F. when operating on tar oil, and special attention to this point is wise when operating at light loads. More cylinder lubricating oil is required with tar oil as fuel. The exhaust valve should be lubricated with kerosene to prevent accumulations of gum on the stem.

Professor Burstall's test of a Crossley Airless Injection Engine, fitted for burning tar oil, gives the results shown in the table.

Burning Fuel Oil Economically

Relation of Furnace Volume to Heating Surface—Increasing the Life of Furnace Brickwork—Absorption of Heat in the Boiler—Oil Temperatures for Mechanical and Steam Atomizing Burners—Pumps and Strainers—Points to Remember

BY FRANK G. PARKER
Combustion Engineer and Furnace Designer

THE rapid adoption of scientific methods in the burning of fuel is due primarily to present-day economic conditions. The marked success attained in the larger plants has no doubt stimulated this development in the smaller plants throughout the country.

It must not be thought that boiler efficiency is the only consideration, or even the primary consideration, leading to scientific control of combustion. While thermodynamic efficiency is of great importance, reliability of operation is, in general, even more essential to success on account of the absolute necessity of continuous service. In this connection it should be noted that the correct distribution of heat greatly increases the life of the furnace and permits the boiler to operate at higher ratings.

FURNACE DESIGN FOR FUEL OIL

Considering first the furnace itself, there are several factors that must be taken into account in designing it for economical and reliable operation with fuel oil. The best commercial results are obtained by so proportioning the furnace that good efficiency may be obtained at ordinary loads, while at the same time the maximum rating may be secured at peak loads without injury to the unit. The average furnace volume should be about 0.2 cu.ft. per sq.ft. of boiler-heating surface, this volume being sufficient for about 300 per cent of rating with the mechanical type of burner and about 200 per cent with the steam-atomizing burner. Where from 0.4 to 0.6 cu.ft. is allowed, as is frequently the case, the added advantage is lost by radiation of heat through the furnace walls and floor, the latter being an important factor in the combustion of liquid fuel. To secure higher capacity with steam-operated burners, the areas of the gas passages must be increased to take care of the greater amount of moisture introduced in the furnace by the steam used for atomization.

The furnace brickwork will fail if saturated with heat at the full furnace temperature possible with liquid fuel; therefore some efficiency must be sacrificed in most cases in order to maintain the furnace brickwork and keep the cost of repairs within a reasonable limit. While suitable refractories are available to withstand considerably higher temperatures, the practice in most plants is, unfortunately, to purchase a relatively low-grade refractory material which must be kept below 2400 deg. F. The only way to overcome this difficulty is to arch the walls to sustain the weight of the brickwork in the tube sections. This has two advantages: In the first place, it permits the bricks in the furnace to be removed and replaced at a minimum expense, and in the second place, it increases the life of the furnace brickwork by reducing the pressure upon it.

Where the furnace is operated under a suction, the infiltration of air serves to prevent overheating. On the other hand, if the furnace is operated under a pressure, there is a tendency for the gases to leak outward, with the result that the brickwork is overheated. If it were economically possible to operate with a slight pressure within the furnace, a higher over-all efficiency of the unit would result.

As already suggested, it is important to reduce the load on walls that are subjected to high temperatures. The reason is that brickwork begins to fail by plastic deformation before it reaches the melting point. The greater the load the lower the temperature at which the wall will fail. For this reason the use of arches in the side walls to sustain most of the weight of the brick in the tube section will permit higher furnace temperatures and higher efficiency.

ABSORPTION OF HEAT BY THE TUBES

The operation of a boiler involves the combined problems of heat generation and heat transfer. In connection with the latter it is helpful to know the laws which govern the passage of heat from hot gases to boiler tubes. Prof. Osborne Reynolds has formulated a law of heat transfer that may be expressed as follows:

$$R = a + b\,\frac{W}{A}$$

where R equals the B.t.u. transferred per square foot of heating surface per hour per degree difference between the temperature of the gas and the metal, W equals the weight of gas per hour, A equals the area of the gas passage and a and b are constants. This law is based fundamentally on the rate of flow of the gas over the heated surface. Subsequent investigators have shown that it is substantially correct.

The following conclusions may be drawn from this law: (1) For a constant rate of gas flow, the rate of heat transfer is proportional to the temperature difference between the gas and the metal; (2) for a given temperature difference the rate of heat transfer increases with increased gas velocity according to a linear law; (3) for a given gas velocity and a given temperature difference the rate of heat transfer increases with the absolute value of the temperature; (4) the rate of heat transfer depends upon the condition of the heating surface; (5) the rate of heat transfer depends upon the size of the channels through which the gas is flowing—the smaller the ratio of the area of the channels to the perimeter of the channels the greater is the rate of heat transfer.

The value of the constant a is influenced by the condition of the heating surface and varies between 1.75 and 2.25 with an average close to 2.00 for reasonably clean surfaces. The value of b is more important. It is

influenced by the ratio of area of channel to perimeter and also by the temperature.

Leaving out of consideration the radiant heat, which does not enter into this formula, it is evident that the amount of heating surface is inversely proportional to R, so that when $\frac{W}{A}$ is, for example, 4,000 lb., a boiler where R equals 18 would have a heating surface only one-third of that of a boiler where R equals 6, the capacity and efficiency being the same for both.

It is readily seen from the formulas given that the condition of the heating surface is of great importance and governs the temperature of the exit gases to a large degree. Therefore, boilers should be equipped with mechanical soot blowers so that the soot may be removed from the tubes before the peak load comes on. The problem of scale should also be carefully handled, preferably by installing a water-purification plant.

The value of the constant b which (as already stated) is more important than that of a, depends largely on the size and spacing of the tubes. For example, the rate of transfer will be greater when four 1-in. tubes are employed than when one 4-in. tube is used, although there is the same total surface in both cases. The reason is that the smaller tubes divide the gases into smaller streams, giving more intimate contact.

Temperature of Oil Important

In burning fuel oil, the question of the temperature of the fuel is important, as it affects the mechanical operation of the burner. With steam-atomizing burners some of the work is done at the burner, but in no case should the temperature be below 150 deg. at that point. The pressure at the pump should range from 75 to 125 lb. for oil up to 18 deg. Baumé. The tip and atomizer must be kept clean and free from carbon at all times if efficient results are to be obtained.

With the mechanical-atomizing type of burner the oil temperature must be sufficiently high to produce satisfactory atomization with a given pressure. The viscosity should be not more than 8 deg. Engler[1] to obtain the desired results. In actual operation the engineer must do some experimenting to determine at what temperature the best results are obtained. If the temperature is too low, the burners will smoke heavily, and no amount of excess air will thoroughly clear up this smoke.

On the other hand, a temperature above what is actually required is not only wasteful, but may cause pulsations in the furnace. These pulsations are also caused by improperly designed furnaces which cause an irregular mingling of fuel and air. These pulsations may become so severe as to limit the capacity at which the boilers can be operated.

A high furnace temperature generally means efficient combustion. One manufacturer recommends the following temperatures for his burners. These should be applicable to all makes of mechanical atomizing burners.

Deg. Baumé	Minimum Temperature, Deg. F.
24 to 30	80 to 100
20 to 24	100 to 140
17 to 20	140 to 160
15 to 17	180 to 190
13 to 15	200 to 220
11 to 13	240 to 270

[1] Viscosity expressed in degrees Engler is a measure of the fluidity of the oil. The less the number of degrees Engler, the more fluid the oil.

The pumping equipment for the mechanical type of burner should preferably be of the rotary type, because fluctuation in pressure will cause mechanical burners to flutter and pulsate. This condition will cause serious trouble during peak loads.

The heater should be of such size as to give the required temperature to burn the oil economically. The piping for mechanical burners should be laid out on the return system, as the oil fed to the burner must be hot to prevent excessive smoke and carbon deposits in the furnace and clogging of the burner.

Return Piping Advisable

The pumping equipment for steam-atomizing burners may consist of either the rotary or plunger pump, since the normal fluctuation of pressure from the latter type of pump has little or no effect on burners of this type. As a rule the heater supplied with the pumping set will be large enough to give the required temperature at the burner. The piping for this type of burner does not have to be laid out as a return system. However, such a layout is of advantage where the boilers are at a considerable distance from the heater.

The strainers used with the mechanical atomizing type of burner must be kept clean and should be of a finer mesh than those used with the steam-atomizing system. The hole in the tip, being of small diameter, is easily clogged. This causes the flame to shoot off to one side and form carbon deposits on the walls and floors of the furnace and on the heating surface of the boiler.

In conclusion, the following pointers on operation of fuel-oil-fired boilers summarize what has been said: (1) Keep the strainers, burners and atomizers clean and the entire apparatus in repair; (2) when a plunger pump is used with mechanical burners, keep the air chamber of the pump properly charged with air, as a steady oil pressure is of vital importance with the mechanical-atomizing type of burner; (3) maintain oil temperatures sufficiently high to secure proper atomizing at the burner; (4) do not use excessively high oil temperatures; (5) maintain a proper balance between the supply of oil and air to the furnace; (6) if all burners are not in use, the ones in service should be selected so as to give the most uniform flame distribution possible; (7) for the mechanical-atomizing burner the adjustment of the impellers and air registers should be uniform on all burners; (8) for the steam-atomizing burner the air spacing or checkerwork under the burner should be so arranged as to let the required amount of air into the furnace, the actual regulation being done with the damper; (9) if an Orsat or other apparatus for analyzing the flue gas is available, a sample should be taken from time to time so that the actual combustion conditions may be known; (10) the burning of oil fuel does not require much actual labor, but it does require intelligent supervision and care. Constant vigilance is required to maintain satisfactory results and low oil consumption.

A simple method of keeping a record of time and duration of hot water or steam blowoff is the installation of a recording thermometer in the blowoff line. This instrument, in this case, being used simply as an indicator, need not be accurate, but may be some defective discarded instrument. When a recording thermometer is not available, a recording pressure gage will often answer.

Correct Adjustment of Unaflow Engine Valve Gear

Description of the Ridgway Unaflow Steam Engine. Auxiliary Clearance Device—How To Time the Valves

POWER is becoming more and more a vital item in manufacturing costs of all industries. When coal was cheap, a reduction in steam consumption of the power plant of even 25 per cent was not always worth obtaining if it meant the investment of any considerable additional capital in the power plant. The rapid rise in fuel costs during the last five years has caused the cost of power to reach a larger percentage of the total cost of the manufactured product than was formerly the case. These conditions have created a market for highly efficient power-plant equipment, and in answer to this demand many manufacturers have taken up the building of unaflow steam engines. These units are quite suited for industrial-plant drive, as their economy at low load is but slightly under that at full load. Not only are they simpler in construction than compound engines of some other types, but in many instances they show a lower steam rate than with the compound; this is especially true on varying load conditions.

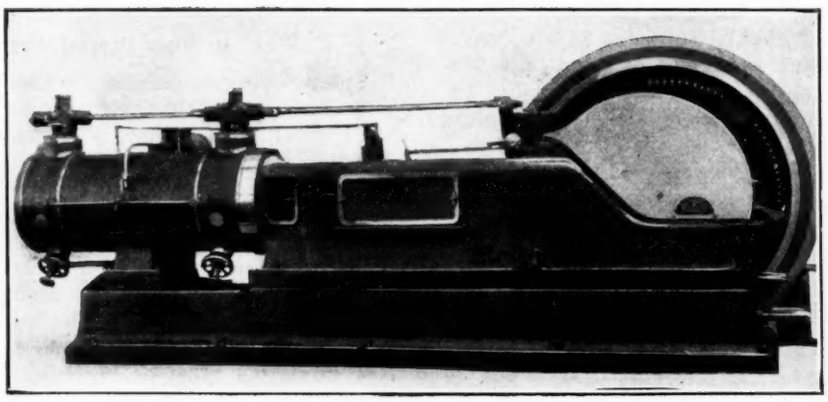


FIG. 1—RIDGWAY UNAFLOW ENGINE

The unaflow engine built by the Ridgway Dynamo and Engine Co. makes use of the Stumpf standardized cylinder design, while the frame is the same as used for years on the four-valve engine of this make, being of the side-crank bored-guide type. The frame is set on a subbase which extends under and acts as a support for the cylinder, as indicated in Fig. 1, an external view of the engine from the crank side. A cross-section of the cylinder is shown in Fig. 2. The barrel is a single casting with flanges at each end to which are bolted the heads and is provided with an exhaust belt around the center. The belt has its outlet at the bottom and rests on a split distance piece on the engine subbase.

The steam valves are placed in the cylinder heads, which are completely steam-jacketed. The details of the steam valve are illustrated in Fig. 4. The valve is turned out of a solid steel forging, and to compensate for any slight variation in expansion of valve and cylinder head, the upper lip of the valve is turned very thin. In this way it is made somewhat flexible. The lower lip seals on a casting bolted to the cylinder head, while the upper lip rests on a seat or ledge machined in the head casting. The stud holding the lower seat casting is extended to fit into the valve body and in this way serves as a guide for the valve, preventing the side pressure of the steam entering the cylinder to throw the valve off its seat when closing. The valve stem passes through a guide that rests in a machine recess in the head. The upper end of the valve stem screws into the crosshead *D*, which is held

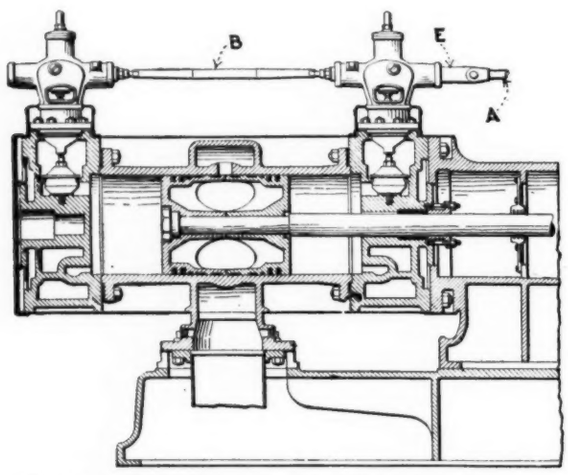


FIG. 2—CROSS-SECTION OF CYLINDER SHOWING LOCATION OF STEAM VALVES

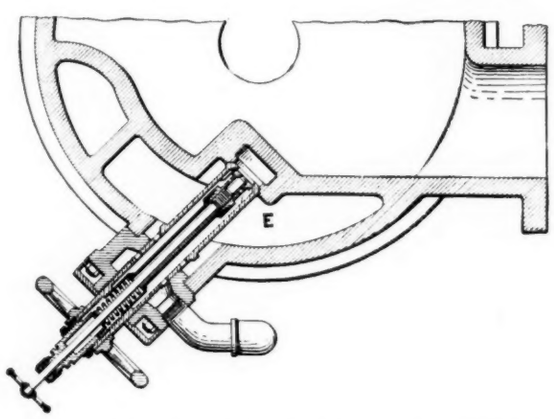


FIG. 3—COMBINED RELIEF AND AUXILIARY CLEARANCE VALVES

*This is the eighth of a series of articles on the unaflow engine. Others appeared in "Power," Oct. 17, Oct. 24, Nov. 7, Nov. 14, Nov. 21, Nov. 28 and Dec. 5. Others will follow.

in the valve bonnet. This crosshead is provided with a cam *C*.

Motion from the governor-controlled eccentric is transmitted through an eccentric rod, rocker arm and reach rod *A* to the cam rod *E*. The rod *E* carries a hardened-steel roller *B*, which, coming in contact with the cam *C*, lifts the cam, crosshead and valve. Closing of the valve occurs when the cam rod reverses its travel and the roller *B* moves under the thin part of the cam *C*.

For condensing operation the cylinder is provided with a combination relief and auxiliary clearance valve, Fig. 3. If for any reason the vacuum is lost this relief valve opens until such time as the operator opens the auxiliary exhaust valve which surrounds the relief valve, putting the auxiliary clearance cavity *E* in communication with the cylinder clearance volume. Engines for non-condensing work have the piston heads made concave for the purpose of providing the necessary clearance volume.

In setting the steam valve, the first step is to locate the dead-center position of the piston by any of the usual methods. The reach rod should now be disconnected and the length of the valve stem adjusted to give a clearance between the cam *B* and roller *C* of 0.002 in. when the roller is under the thin section of the cam. If a greater clearance is given the roller, there will be a pound when the roller strikes the cam while the engine is running.

The reach rod *A* should now be reconnected to the

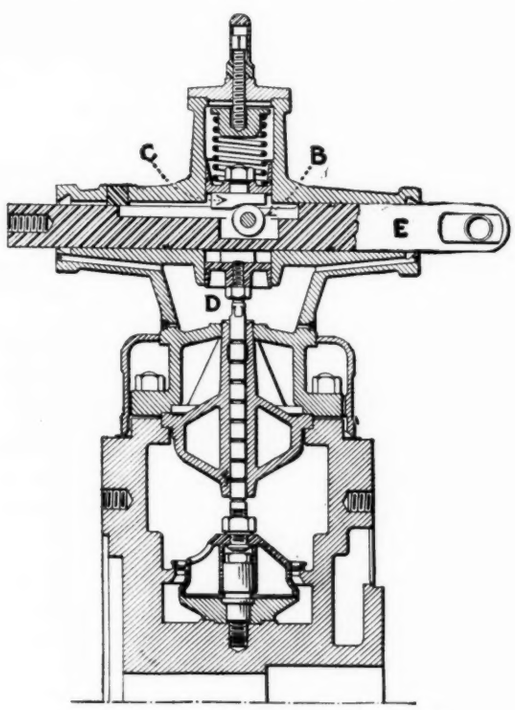


FIG. 4—DETAILS OF STEAM VALVE

cam rod *E* and the engine turned over until it lacks one per cent of its stroke of reaching crank dead center. This is the *lead* point, and the reach rod *A* should be adjusted to cause the valve to just start to lift at this point. The engine is then turned on over in its running direction until it is one per cent of the stroke from head dead center. The head-end steam valve stem is now set to cause the valve to start to open. This adjustment is made by altering the length of the tie rod connecting the two cam rods, which has right- and left-hand threaded ends.

After the valves are set up, the engine should be run for a time and indicator diagrams taken. If the lead is too much or too little, the necessary correction

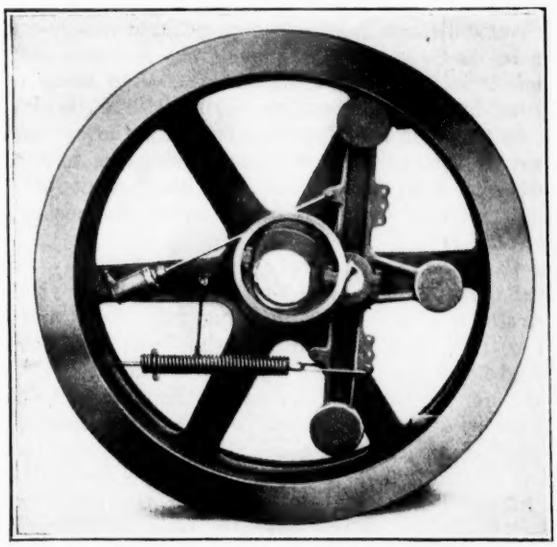


FIG. 5—SHAFT GOVERNOR USED

in the timing should be made. It is advisable to check the cam clearance when the engine is hot. The cam and roller must have a clearance or the engine will take steam full stroke.

Mechanical Atomization of Fuel Oil

A number of tests were recently made in order to determine the quantity of fuel oil that would pass through a $\frac{1}{16}$-in. orifice at different temperatures and the character of fires resulting. The fuel oil used was 20 degrees Baumé with a flash point of 220 deg. F. The fuel-oil pressure was 200 lb. gage.

RESULTS

Temp., Deg. F.	Lb. Oil per Hour	Remarks
60	340	Poor atomization
110	440	Bad sparking
153	375	Good flame
210	330	White and short
260	300	White and short
304	273	White and short flame 2 ft. long

The burner used was one of the modern mechanical burners of which there are a number on the market.

Trouble is oftimes experienced with corrosion of the valves of vacuum pumps, due to the moisture in the air and gases that are handled. This may be remedied by the installation of a baffled tee in the suction just ahead of the pump. This separator should be fitted with a drain at the lowest point so that any collection of moisture may be periodically drawn off.

The total amount of electrolyte required in each cell of a storage battery depends upon the total range of change of specific gravity allowable, more being required if the change is to be less; but for power-plant batteries, approximately ten pounds of electrolyte per cell is required for 100 ampere-hours of battery capacity on normal 8-hour discharge rate.

The Lubrication of Diesel Engines

By W. F. OSBORNE
Supervisor, Manufacturers' Service, Texas Company

THE lubrication of the Diesel engine is not such a very difficult matter when suitable oils are used. In fact as far as the power cylinder is concerned, it is less difficult to lubricate than many other types of internal combustion engines. This is due, in part, to the fact that the fuel entering the cylinder is burned as fast as it is delivered and there is not the opportunity for dilution of the lubricating oil film on the cylinder wall that occurs with engines of the carburetor type.

On the compression stroke, instead of there being a fuel mixture in the cylinder, as is the case with the carburetor engine, there is nothing but air, diluted perhaps with a little burned gas that was not entirely removed from the cylinder on the previous stroke. The compression of this air has no particularly bad effects on the lubricating oil, except such as may come from the high temperatures reached as the piston nears the end of its stroke. These temperatures are considerably higher than exist at the end of the compression stroke of engines of the explosive type, and there is a greater tendency for the oil to evaporate or to decompose.

Overcoming Decomposition Tendency

In general, this tendency can be overcome by the use of sufficiently viscous oils and oils of reasonably low volatility. It is better to use an oil which evaporates a little rapidly if it will do so cleanly without decomposition and the formation of carbon deposits. Such deposits on the rings are particularly undesirable, as they prevent proper cooling of the rings and pistons, resulting in temperatures high enough to burn the metal. Those engines that have been in continuous operation for over a year at a time, without any deposits building up to interfere with the satisfactory operation of the engine, needless to say, were lubricated with an oil that was suitable in every respect.

Some Diesel engine cylinders are lubricated by mechanical force-feed lubricators, arranged to supply the oil to the right point on the cylinder wall. Through proper regulation of the oil feed it is possible to keep the quantity down to the minimum required for satisfactory lubrication. When the cylinders are lubricated by the oil splashed from the crankcase, care must be exercised to see that too much oil does not enter the cylinders. Excessive feed of oil will cause carbon deposits and stuck rings, as it cannot evaporate as rapidly as it is supplied.

Bearing Lubrication

Bearings are frequently lubricated from a force-feed pump which takes the oil from the receiver and delivers it to the bearings under pressure; the oil then drops into the crankcase and drains to a filter. Such crankcase must necessarily be fully inclosed to prevent loss of oil. On some types of engines a centrifugal oiler picks up the oil from a feed line and delivers it to the bearings under a slight pressure due to centrifugal force; the oil then drops into the crankcase and is passed through a filter and used again.

Since there is more or less accumulation of foreign matter in the oil which is continuously used, and sometimes also dilution of the oil by liquid fuel finding its way past the piston, it is always advisable to equip the circulation system with continuous filters to remove the foreign matter. By keeping the oil in good condition, it will last longer and there will be less wear of the bearings.

Lubrication of Diesel Air Compressor of Great Importance

The Diesel engine has one feature which the other types of internal-combustion engines do not have, and it is the cause of many of the troubles with lubrication. This is the air compressor. Although the final pressure is high, 700 to 1,000 lb., if the various stages are properly designed and suitable intercoolers are used, the temperature should not reach a high degree at any point. So long as the temperatures are not excessive, the same oil that would be used ordinarily for air compressors handling equivalent temperatures and pressures should give satisfactory results.

The principal point to watch in the lubrication of Diesel air compressors is the quantity of oil fed. The amount of air compressed is small as compared with the familiar power-plant air compressor, and engineers are prone to forget that all the oil going into the low-stage cylinder also must pass through the intermediate and high-pressure stages before it can get out. If it stays too long, it is going to carbonize. It must evaporate slowly, because the quantity of air to take it up is so small. This means that the oil should be fed very sparingly to the low-pressure cylinder, and in many cases not at all to the other stages.

Rate of Oil Feed

Elimination of excessive oil feed will prevent most carbon deposits and sticking valves with their attendant troubles in air-compressor operation. If for any reason it is not possible to reduce the oil feed to the low-stage cylinder sufficiently to prevent an accumulation of oil in the intermediate or high-pressure stages, carbon deposits can sometimes be prevented by putting a drain valve in the lowest part of the cylinder so that the excess oil can be drained out at regular intervals. This regular draining removes the oil before it has had time to carbonize.

When certain types of oils are used, it is possible to use the same oil in the power cylinder and in the compressor. On many installations the same oil can be used for the bearings also, in this way permitting the use of one oil throughout. Such an oil will be a highly filtered straight-run of a proper viscosity to suit the mechanical construction of the particular engine. Most Diesel engines can be lubricated with an oil of 700-800 seconds Saybolt at 100 deg. F. Some other types can use a lighter-viscosity oil of about 500 seconds.

Occasionally, it is found desirable to use a low-viscosity oil in the circulatory oiling system for the bearings where the engine is so designed as to permit the use of separate oils for cylinders and bearings. The low-viscosity oils filter readily and are usually less expensive.

EDITORIALS

Boiler-Room Control

ONE of the main problems in operating a large power house is the control in the boiler room. In hand-fired plants this is a personal problem with each individual fireman. Draft indicators, CO_2 recorders and other devices are provided to assist the fireman in securing and maintaining proper conditions in the furnace and thereby maintaining highest boiler efficiency.

The mechanical stoker presents a quite different set of problems. Coal can be furnished either regularly or at varying speeds as desired. The leading requirement now is to proportion automatically the quantity of air entering the furnace to the amount of coal supplied, and to have this ratio maintained for varying load conditions on the boilers. Naturally, the first attempts to attain this end followed good standard practice in hand firing. Draft gages, CO_2 recorders, etc., were installed, but the amount of air entering and the amount of coal supplied were governed by hand regulation of dampers and stoker-engine throttle valves. Dependence was still largely placed on the personal ability of the fireman.

The big problem is to provide fully automatic regulation of the furnace as dependable and as certain of obtaining the desired results as the governor on an engine or turbine. Peak loads and sudden removal of loads must be met with equal effectiveness. This seems a large order and it is true there are certain fundamental limitations in boiler furnaces. There is the inert ash and clinker to disturb control and also the heat stored in the brick side walls. With powdered fuel, oil fuel or gaseous fuel automatic regulation is not as difficult to obtain. There are difficulties with coal furnaces, though some very excellent devices have been developed that endeavor to meet these conditions.

An analysis of operating conditions may suggest a possible solution. One recognized method of handling a boiler to meet variations in load is to operate controllers from changes in the boiler pressure. Normally, the controller speeds up the forced-draft fans. These furnish increased quantities of air at increased pressure to the stoker windbox. Apparantly, the stoker should furnish additional coal in proportion to this increased air flow, and the rear damper should open proportionately to pass the increased volume of flue gases. This apparently simple relation is not satisfactorily attained in practice for variations in depth of fire or presence of accumulated ash and clinker completely upsets the balance of the scheme. For instance, increased depth of fuel bed requires increased draft at increased fan speed, but not necessarily increased stoker speed, as this would further aggravate the difficulty.

Another suggested solution is to have the fan under pressure control, but to govern the rear damper from the pressure in the furnace itself. The opening of the rear damper will then be directly proportional to the volume of gases leaving the boiler, and if the stoker engine control is operated from this main damper, there should be a direct relation between the air passing through the fire and the coal fed to the furnace. This plan, however, has one grave defect. Various grades of coal require different quantities of air, and this can generally be secured only by an elaborate readjustment of the control mechanism. Possibly an improved design of control capable of ready adjustment coupled with CO_2 indicators or other devices will produce a mechanism closely approaching the automatic control desired.

Improving Power Plant Efficiency

THERE are three ways of improving power-plant efficiency—maintaining the efficiency of the operating cycle, selecting the proper equipment, and improving the equipment by changes in design. Although in coal-burning plants over-all thermal efficiencies of about twenty per cent have been obtained under favorable conditions, even in the largest plants the average for a year is far below this figure. Fifteen per cent is about the best that the average large station is doing, with many plants, having ratings for twenty thousand to thirty thousand kilowatts capacity, operating at ten per cent or less. Instead of producing a kilowatt-hour on seventeen or eighteen thousand British thermal units, the average figure will be from twenty-three thousand to over thirty thousand.

The wide range between the figures of what can be done and the average results obtained, indicates anything but high maintained efficiency. There are many conditions in plant operation that tend to reduce the average over-all efficiency; some of them are controllable and others are not so readily handled. Load factor undoubtedly has an effect, but cases are on record where, in plants of considerable difference in size, the smaller plant operating at about forty per cent and a larger one at sixty per cent load factor, the smaller plant showed thirty per cent less coal consumption per unit output than the larger station. Even though these conditions may exist, taking two plants that are alike as to equipment, if both are operated with equal proficiency, the station with the highest load factor will develop the highest over-all average efficiency.

For years it has been possible to obtain an over-all boiler-and-furnace efficiency of over eighty per cent with large stoker-fired boilers without the use of economizers, yet the average in many of the large plants is down around sixty-five per cent or less. There are a few exceptions to these figures where efficiencies up to about seventy-seven per cent have been obtained without the use of economizers. The maintenance of equipment has a marked effect on over-all efficiency and is very largely under the control of the operating force. If condensers are kept clean and tight, the boilers kept clean, steam and hot-water leaks prevented and all steam and hot-water lines well insulated, the average heat units required per kilowatt-hour on the busbars will be materially reduced.

The wide difference in average operating efficiencies of two plants under similar conditions can be attributed to operating methods and the selection of the kind and size of equipment to serve the load. When selecting

equipment, it is not always possible to obtain the arrangement that will give the highest over-all efficiency, or engineers have not felt justified in doing so. All electric drives for the auxiliaries and bleed the main turbines for feed-water heating will give a higher over-all economy than using steam-driven auxiliaries. The possibilities of the station going dead have deterred power-plant engineers from taking full advantage of benefits to be obtained from this arrangement. Then again there is the matter of cost. Will the installation of equipment that will reduce the coal consumption reduce the kilowatt-hour cost at the switchboard?

Present indications are that in the near future no radical improvement in efficiency may be looked for in the design of power-plant apparatus, although the substitution of a regenerative cycle for the Rankine and going to higher steam pressures offers possibilities that are encouraging. However, before the full benefit of these is obtained, there is much development work that must be done.

While power-plant engineers are waiting for the higher economy to be obtained from new designs, the present differences between the average over-all plant efficiency and that which can be obtained with present design of apparatus offers a fruitful field for careful study and improvement.

Safe Pipe Bends

AT THE convention of the American Society of Mechanical Engineers perhaps one of the most valuable contributions to the power-plant field was the paper on the "Elasticity of Pipe Bends," by Messrs. Crocker and Sanford. In the running report of the convention in this issue a brief summary of this paper is published, but to those interested in the mathematical demonstrations and in the charts presented, the paper in its entirety will be available of course in the proceedings of the Society.

As expressed by the authors, the disposal of expansion and contraction in power-plant piping up to the present time has been largely a matter of judgment rather than rational calculation on the part of the designer. This perhaps may have been all well enough in the past, but as steam pressures and temperatures in turbine practice continue to mount, the problem of providing for the excessive stresses that may be set up, becomes more and more important.

From the safety viewpoint alone it is imperative that the designer know how to calculate the forces involved and to use this information in laying out the piping system. The authors have developed a rational method of attacking such problems and show wherein their methods and results differ from the work of previous contributors to the subject. Treating expansion bends in pipe lines as if they were beams acted upon by the forces set up by the expansion of the piping, formulas were derived for the forces and stresses in some of the more common types of bends, and to check the formulas several bends were tested by applying a force to one end of the bend and the force and deflection measured.

All data obtained are expressed graphically for convenient reference, and the formulas are presented in chart form for use in selecting the proper shape and size of the bend to take up a given expansion. From the light of the information given in the paper, it would appear that the limits of safe expansion values for pipe bends commonly quoted in engineering texts and handbooks, are correct only for the double-offset expansion U-bend. For other shapes the published values are much in excess of those determined by the authors. Therefore, it is their contention that unless the published tables are used with large factors of safety, the forces and stresses existing in pipe lines will be excessive and dangerous.

In recent years the increasing number of mishaps to pipe lines tends to confirm this conviction, and unless the pipe line and fittings are to be the weak link in the chain, designers of high-pressure steam systems will do well to give careful attention to the paper under discussion.

Progress in the Art of Conveying and Measuring Fluids

ENGINEERS have long realized the fundamental importance of the laws governing the flow of fluids such as water, air and steam. There is, however, still room for much work in this field. That research workers are actively engaged in filling in the gaps is evidenced by the fact that three papers on various phases of the subject were presented at the recent annual meeting of the A.S.M.E. These dealt, respectively, with the transmission of superheated steam, coefficients for flange orifices and the effect of pulsations on the readings of flow meters. Each of these papers gave information of great practical value.

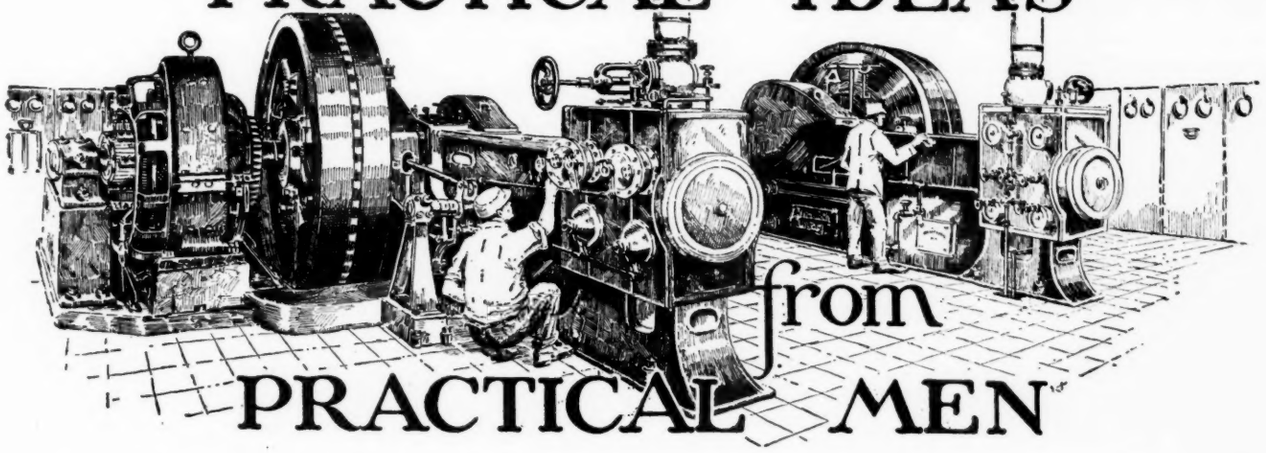
That on superheated steam, for example, helped to fill the gap that has existed in our knowledge of the heat losses and pressure drops in steam lines. While many experiments have been made with saturated steam at moderate pressures, but little information has been available for steam at high pressures and superheats. Much work remains to be done, but the data given in this paper will make possible the more rational design of steam lines under the conditions found in the large modern plants. The experiments already made show that considerably higher velocities may be used with superheated than with saturated steam. This means a corresponding reduction in pipe size, heat losses and first cost.

In view of the growing importance of flow meters for the measurement of steam and air, the two other papers were perhaps of even greater practical importance. That on orifice coefficients gave a complete set of constants for the measurement of air flow by flange orifices. The data given were so comprehensive that they may be applied to any sized orifice in any size of pipe.

The other paper on flow meters attacked, and, to a great extent, solved a difficulty that has limited the universal application of flow meters. Reference is here made to pulsations in the fluid being measured. These, particularly in the case of steam supplied to (or air delivered by) reciprocating machines, results in "high" readings with all types of flow meters. The experiments made showed not only the amount of error caused by pulsations of various amounts and frequencies, but also the effectiveness of the various methods of reducing the pulsations before the fluid passes to the meter.

It is to be hoped that the practical data given in these papers will inspire other experimenters to continue the work along similar lines until the flow and measurement of steam and air are based on as solid a foundation of science as that which now underlies the applications of hydraulics.

PRACTICAL IDEAS from PRACTICAL MEN



How Is the Leakage Past the Piston Best Determined?

I would like to have some suggestions from readers of *Power* as to the best method of testing the steam end of small Duplex reciprocating piston pumps to determine the leakage of steam past the piston rings.

I have on some occasions, when I knew the rings to be worn, disconnected the valve rods, placed the valves in the proper position, moved the pistons to the middle of the stroke, and blocked them, removed the cylinder head and turned on the steam. This shows the leakage of steam past the rings, but after putting in new rings and again testing the steam cylinders, we can hardly notice the difference in the quantity of steam. This, of course, is probably due to the walls of the cylinder not being perfectly true.

Possibly some reader can give a more practical method of determining approximate quantity of steam lost in this manner C. C. MOORE.

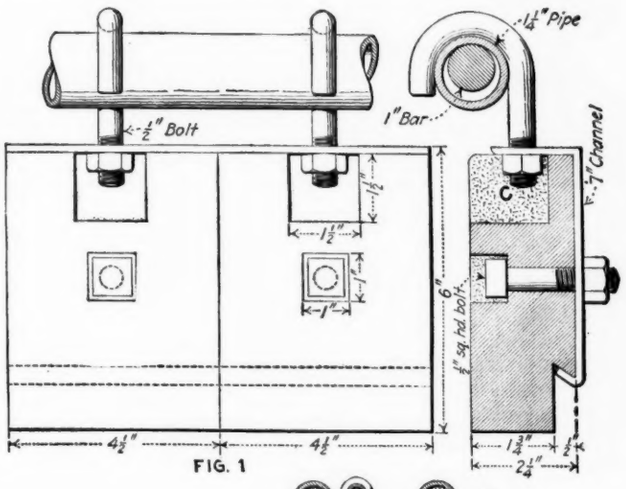
New York City.

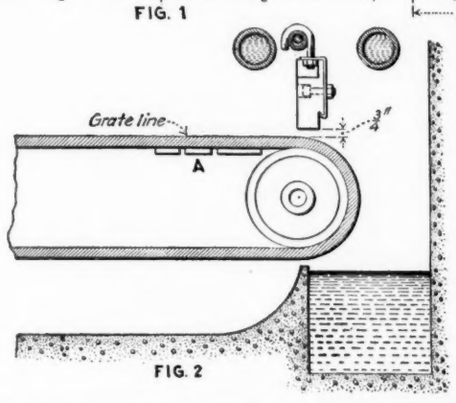
Swinging Damper Reduces Air Leakage at Rear of Chain-Grate Stokers

In the operation of our stokers the ash and clinker that are carried over the rear end of the grate fall into a trench through which some of the condenser circulating water is discharged. As the water carries off the refuse to an outside pit, it was necessary to provide some means of automatically closing the space between the bridge wall and the stoker to prevent the inleakage of air.

The initial method consisted of sections of channel iron suspended from hook bolts, but the life of the section was from five days to two weeks, due to their burning off. These sections were then packed with plastic cement and fireclay, but the results were still unsatisfactory owing to the cracking of the packing, exposing the metal to the furnace temperature.

The plates were then cut and bent as in Fig. 1, and a standard firebrick cut to fit and fastened to the plate by a bolt in the center. In case the brick cracks through the weakest section at the holding bolt, it is sufficiently clamped to prevent falling out. The bolt heads were finally covered with a mixture of loose asbestos and cement to protect them from the heat of the furnace. The top of the bricks were cut as at *C* to allow adjusting the height of the damper above the grate, and the damper was finally suspended by hook bolts from a pipe reinforced with a bar, and located close to the waterback. As the demand on the boiler during the period of lightest load is about half the normal capacity and as the stokers are equipped with adjustable dampers as at *A* to decrease the grate surface during this load, the depth of the ash on the grate during that period was taken for the clearance between the damper and the grate, or approximately ¾ in.





DAMPER IS CONSTRUCTED OF CHANNEL IRON AND INSULATED WITH FIREBRICK

The demand on the boilers varies over a wide range,

and since the installation of the damper no trouble has been experienced in discharging the ash or in keeping the excess air down to a reasonable point. After three months' operation no deterioration was apparent other than a slight adhering of clinker to the firebrick, so slight that it did not warrant removal.

Sterling, Colo. JOHN J. MONAGHAN.

Testing Apparatus for Determining Percentage of Moisture and Ash

Where the coal for a power plant is purchased on the basis of analysis and calorific value, it requires considerable skill, costly apparatus and a fair knowledge of chemistry in order to make a complete proximate analysis with accuracy. However, as the ash, by displacing combustible, has a direct bearing on the heat value of a coal, in many plants the percentages of moisture and ash only are determined, and with the addition of a chemist's balance (accurate to 1 milligram) to the equipment shown here, the percentage of moisture and ash can be determined by any engineer.

In plants where city gas is obtainable the bunsen burner is most commonly used for this purpose, but where this service is not available the equipment shown here can be readily constructed and will give good results.

The drying oven shown in Fig. 1 is similar in detail to the standard oven usually supplied with laboratory equipment for this purpose. If a standard oven is not available, one can easily be made up from sheet copper or sheet iron of the general design shown, the dimensions of which are approximately 6 x 6 x 7 in., and fitted with two perforated trays and a door. An opening is cut in the bottom of the oven to receive a piece of tin or sheet-iron pipe of suitable size and length to go over a 32-cp. carbon lamp. The oven is placed on two light iron brackets fastened to a wooden base, which also carries a porcelain receptacle for the lamp and is connected to the lighting circuit through a snap switch.

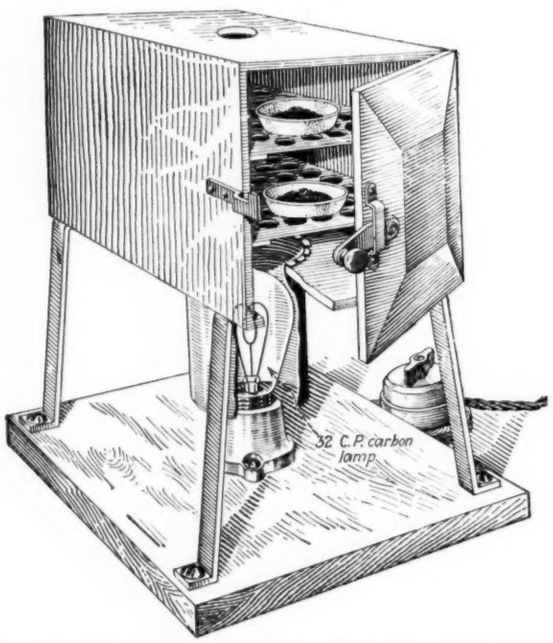


FIG. 1—THE HEAT RADIATED BY THE LAMP CAUSES AIR TO CIRCULATE THROUGH THE OVEN, GIVING A TEMPERATURE OF 180 TO 200 DEGREES

The burning equipment shown in Fig. 2 consists essentially of a tank of 10 gal. capacity connected by ¼-in. pipe to the gasoline burners supported as shown. The gasoline line is extended inside the tank to within a few inches of the bottom. A hand air pump is connected for creating an air pressure of 10 to 12 lb. in the space about the gasoline.

The screen for supporting the crucibles is made adjustable so that the height above the burner can be regulated to obtain the best burning. This is usually around 1 in. If burners with a curved tip as shown cannot be obtained, a straight burner can be used by simply adding an elbow of suitable size to the end to give a vertical flame.

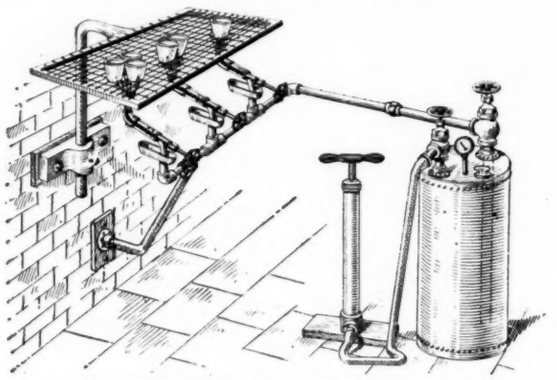


FIG. 2—THE REGULAR GASOLINE-TORCH BURNERS ARE USED, AND 10 LB. AIR PRESSURE IS CARRIED ON THE TANK

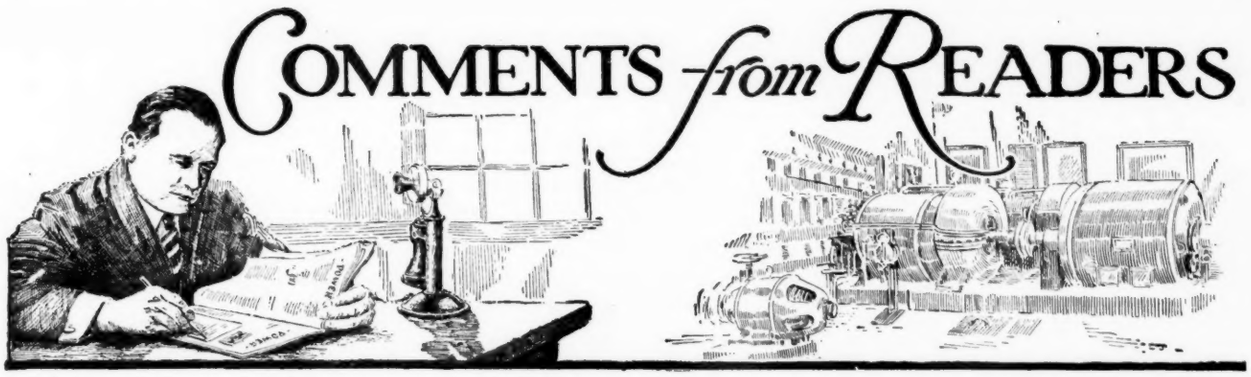
To test a sample of coal, first grind reasonably fine, then weigh out 10 grams on the balance and pour into a shallow porcelain tray and place in the oven, allowing it to remain there for about twenty-four hours. If the door of the oven is kept closed, a temperature around 200 deg. will be maintained and several samples can be placed in the oven at one time. When the sample is removed from the oven, weigh it again, and the loss in weight divided by the original weight of the sample will be the percentage of moisture.

Now, to obtain the percentage of ash in the coal, from this dry sample weigh out, say, 6 grams and divide it into three crucibles and place over a burner for two or three hours. The time required, however, for burning depends somewhat upon the free-burning or coking characteristics of the coal. A smaller or larger sample of coal may be used and is optional.

When the sample is completely burned to ash, allow it to cool and then weigh as before. The weight divided by the original weight of coal gives the percentage of ash per pound of dry coal. By using more than one burner a sample of refuse from the ashpit can be tested for the percentage of combustible at the same time as a sample of coal is being burned. Care should be exercised to obtain true samples of either coal or refuse.

Cleveland, Ohio. E. A. CURTIS.

An effective method of reducing the flash and water loss from a steam exhaust to atmosphere is to install a 12-mesh brass screen across the diameter of the exhaust head through which the exhaust steam passes. Over this screen at a distance of about twenty inches install one or more inverted cold-water garden sprays. Enough sprays should be installed so that the entire arch of the screen is covered.



Behavior of A.-C. Generators When Field Circuit Is Opened

I have read with interest H. G. Robert's letter on page 775 of the Nov. 14 issue, and it brings to mind a demonstration of this phenomenon that I staged quite a few years ago. I had just completed the installation and was starting up three 1,000-kva. 514-r.p.m. 480-volt vertical alternators direct connected to waterwheels. The customer had a number of synchronous motors on the system, and it was almost impossible to make the operating force appreciate the necessity of proper field regulation and that changing the field excitation did not alter the mechanical load of the motors or the output of the generator. I, therefore, took No. 1 and No. 2 generators, synchronized them on the bus without load, adjusted the fields of both machines so they had the same field current and a bus voltage of 480.

The field on No. 1 generator was then slowly weakened and on No. 2 the field strengthened a corresponding amount, all the time holding 480 volts on the bus. This was continued until the field switch on No. 1 was finally opened. The tachometers on the machines and the frequency indicator on the bus showed that they were running at the same speed with about full load exchange of current and proper bus voltage, No. 2 supplying field excitation for both machines, with something over twice normal no-load field current.

I then went to No. 2 generator, disconnected the governor and shut the gates; the governor of No. 1 opened up a corresponding amount, and otherwise the outfit ran as before. This left No. 2 generator running as a synchronous motor on the system with its field over-excited and exciting the field of No. 1 by supplying a leading current to this machine. The field switch was then closed on No. 1, the field current brought slowly back to normal with No. 2's field current reduced proportionately. The governor on No. 2 was then cut back into service and the two machines left running in parallel as at the start.

A running fire of comment was made, with proper explanations all during the demonstration, and the operating crew, apparently, had a much better understanding of the functions of the field rheostat and governor adjustments.

The two machines as connected on the bus were not supplying external load outside of two small motors driving oil-pressure pumps for the step bearings. The full-load currents that are referred to were practically all wattless, transferring magnetism between the two machines plus the small amount of current required to drive No. 2 generator as a synchronous motor.

The gates in this particular wheel were of a cylindrical type, so when they were completely closed there was very little if any water going through the wheel. In fact, the test was run only a few minutes for fear that there might be rubbing between the waterwheel parts which ordinarily are lubricated and cooled by the water.

N. L. REA,
Construction Engineer.
General Electric Co.,
Schenectady, N. Y.

I read the article in the Nov. 14 issue on "Behavior of A.-C. Generators When Field Circuit is Opened" and wish to submit the following:

Some time ago we lost the field current on one of our alternating-current generators, at which time there were in operation three machines in parallel—one 2,500-kva. 1,500-r.p.m. steam-turbine-driven unit, one 1,000-kva. and one 500-kva. machine. The two latter were driven by synchronous motors; all were three-phase machines, generating 6,600 volts at 25 cycles. These machines are used to supply single-phase power for a railway system and the load is more or less fluctuating. The field of the 2,500-kva. alternator has a heavy copper damping winding and is especially constructed for single-phase service. But at that time the average load was about 1,500 kw. and a Tirrill regulator was used to keep the voltage constant. Things had been running normally, when the voltage suddenly dropped to 4,500 and the steam-driven unit dropped to about 400 kw., the remainder of the load being carried by the other two.

Being three-phase, there were three ammeters on the steam unit's panel, and normally but two of them show any reading due to the single-phase load, but the three meters now indicated a balance load showing about 250 to 300 amperes on each wire. This was a heavy current for 400 kw. at 4,500 volts, as it makes the output of the machine equal to from 1,950 to 2,350 kilovolt-amperes and the power factor from 0.17 to 0.20. The voltage was normally 6,600, but had now dropped to 4,500 with a very low leading power factor, although the power factor we were not sure of because the power-factor meter on the turbine-driven unit was unreliable at that time. The power factors on the other two machines were extremely low lagging as indicated by their meters.

The steam-driven unit was taken off the bus, and the voltage and power factor immediately returned to normal on the remaining two machines. Later, the field circuit was tested on the steam unit and found open. On dismantling the alternator, one of the conductors running from the collector rings to the field winding was found burned open.

It is evident that this machine, with its governor set to take about 1,000 kw. of the load, when it lost its field current ran somewhat above synchronous speed and generated 400 kw. as an induction generator, taking a heavy magnetizing current from the other two machines. It might be stated that the speed of the unit was noticed to increase somewhat when it lost its field current.

E. B. HEISE.

Michigan City, Ind.

Metering Boiler-Feed Water with Direct Steam Pump

In the Nov. 14 issue, the answer given to the inquiry of M. J. M. in reference to metering boiler-feed water with a direct steam pump is undoubtedly correct, but in many plants it is not possible to make a perfect test and it is up to the engineer to make tests with the appliances at hand and make corrections as close as possible. A simple test can be made by installing a tee in the feed line between the boiler-feed valve and the pump. To the outlet of this tee connect another tee fitted with a pressure gage and a valve. Connect the discharge of the valve to a suitable measuring tank or into a barrel placed on a scale. When ready to make the test, close the boiler-feed valve and at the same time have the valve to the tank opened just sufficiently to maintain boiler pressure on the gage when the pump is running at the average speed. Allow the water to discharge through this valve for a certain number of strokes and then weigh. The weight of water divided by the number of strokes will give the discharge per stroke, and the result will be a fair approximation and will in many cases answer the purpose.

Brooklyn, N. Y. C. A. ENGGREN.

What Is the Best Design of Firebox?

The article in the Nov. 21 issue on "What Is the Best Design of Firebox," brings up a point that should be of interest to all power-plant engineers and to those interested in boiler plants in general.

The author advocates among other things the placing of the firebox outside of the boiler setting and dropping the boiler to a lower level so that gage readings may be more readily discerned, boiler-setting costs lessened and simplified, and the design of the firebox treated as a thing apart from the boiler.

It is my opinion that the firebox should receive consideration as well as the boiler or any other equipment necessary to the production of steam energy, but I do not believe the shifting of the firebox from under the boiler to a point on the outside would be an advantage even though great care were taken to insulate and redesign the settings.

By the introduction of flues or passages to convey the hot gases from the firebox to the boiler tubes, there would enter into the problem the loss of heat due to the surface contact of the gases with the flue walls and the resultant radiation of this heat to the outer air of the boiler room.

The distance from the firebox to the boiler tubes would be much greater with consequent cooling of the gases and would introduce the use of a greater amount of coal to bring the boiler into operation after a banked-fire period. Also there would be the disadvantage of not being able to utilize the high temperatures directly over the fire as a means of contact heating of the boiler tubes. This heat would tend to dissipate itself in the top of the firebox before it came into any contact with the boiler tubes.

Due to the flues and passageways not being of large cross-sectional area, the gases would require additional draft to force them to the rear of the boiler and over the boiler tubes.

With reference to the boiler setting it can easily be seen that the same floor area would be required as exists at present, and additional floor area would be necessary to care for the outside firebox.

With the present boiler and firebox designs the amount of heat dissipated before it reaches the boiler tubes is small as compared to those losses which would result if the natural upward flow of heat were disregarded and "piping" of the heat over longer distance were resorted to. The ideal method, in my opinion, would be to work toward a design wherein the gas-travel from the firebox to the boiler tubes would be as short as possible and the utilization of a high percentage of the heat assured before loss by conduction and radiation can occur in the firebox and boiler.

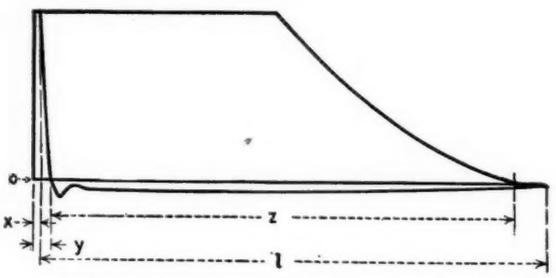
NATHANIEL W. BLANCHARD.

Inwood, Long Island, N. Y.

A Peculiar Design of Air Compressor

Referring to the article by R. McLaren in the Oct. 3 issue describing an air-compressor cylinder with bypass ports, there are two possibilities:

First, that the designer feared air would be trapped in the cylinder end at an excessive pressure. However,



DIAGRAMS OBTAINED FROM AIR COMPRESSOR

it is improbable that this is the object, since the obvious and usual design of a port extending to the cylinder head covers this fully.

The second solution is that he went astray on volumetric efficiency, that he made a discovery of a new method of obtaining increased compressor efficiency and proved it to his own satisfaction by indicator cards.

Obviously, the ideal machine would take a cylinderful of air at atmospheric pressure, compress it without loss and deliver all of it at the high pressure. By means of these ports the remnant of the high-pressure air in the clearance space fills up the other end—giving a cylinderful of air at atmospheric pressure. Normally, of course, the volume X expands to the volume Y and the piston, returning somewhat before atmospheric pressure is again reached, gives a net volume Z of air at this pressure—and $\frac{Z}{L}$ as the volumetric efficiency. Instead of this the pressure of the assumed waste air drops more quickly instead of apparently re-expanding in the same end. If the ports were closed until the piston came to rest, there would be a good beginning for a

favorable argument. If the ports were small enough, this would give practically a square-cornered, good-looking card. Two ports were needed in the low-pressure cylinder to bring the suction pressure up to atmospheric pressure by the end of the stroke by this bleeding of the discharge into it.

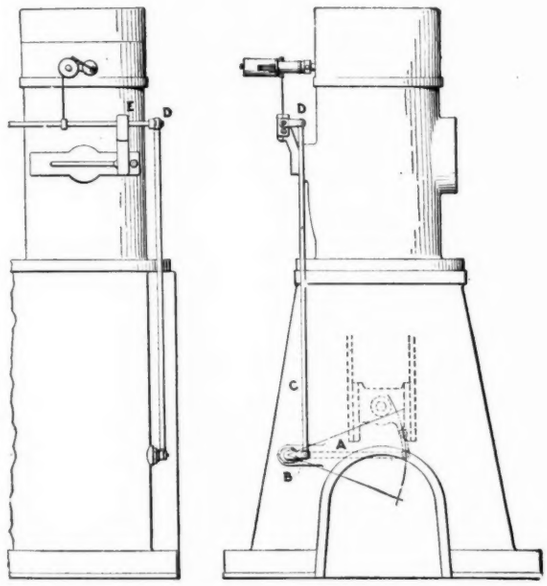
Pullman, Wash., A. R. NOTTINGHAM

Indicator Rigs

In *Power*, Nov. 7, 1922, were shown several methods of connecting indicators to the Diesel engine. I noticed with a good deal of interest that in all cases the indicator rigging was connected directly to the engine piston or crankshaft. The necessity of this direct motion was not pointed out, and I believe engineers should be made aware of the danger of using a complicated or indirect rigging.

In the illustration appears a rig used by one engine builder. A link pinned to the engine crosshead transmits the piston motion to the lever *A*, which, through a short arm *B*, a vertical rod *C*, a bell crank *D*, and a shaft *E*, pulls the indicator drum cord. This in appearance is very neat, but after a short time the slight wear at the joints causes the indicator diagram to be unreliable. A diagram showing almost any desired characteristic may be obtained.

In still another factory the indicator cord is led off a pin on the end of the camshaft. This shaft is driven through helical gears from the crankshaft. The cord must necessarily be some fifteen feet long and makes



INDICATOR RIG THAT TENDS TO DISTORT THE DIAGRAM

three turns in order to reach the end cylinder. The diagrams with this arrangement are deceptive and cannot be depended upon.

While for the purpose of calculating the m.e.p. and the indicated horsepower, an indicator diagram is necessary, still the tendency at present is to disregard indicated horsepower and base the engine's power and efficiency upon the brake horsepower.

For the purpose of studying the combustion events, the best indicator diagram is that obtained by pulling the drum cord by hand in such a manner that the portion of the diagram covering the combustion period is much elongated. G. GROW.

Philadelphia, Pa.

Comparison of Coal and Oil Fuel Costs Under Steam Boilers

As the comparative cost of coal and oil as a fuel under steam boilers is somewhat of a live topic at the present time, the chart here shown may be of interest. It was figured out from tests made in the plant of a New England manufacturing concern. The results

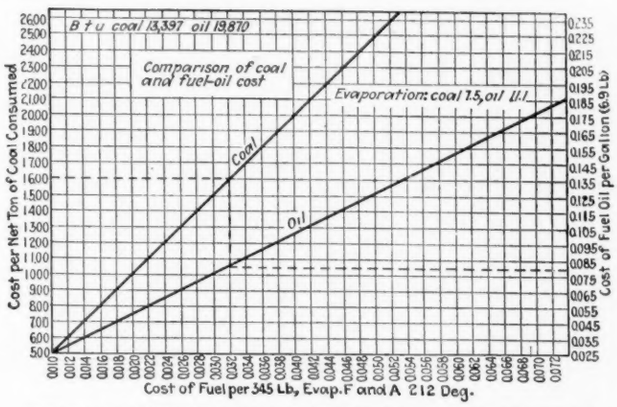

B t u coal 13,397 oil 19,870
Comparison of coal and fuel-oil cost
Evaporation: coal 7.5, oil 11.1
Coal
Oil
Cost per Net Ton of Coal Consumed
Cost of Fuel Oil per Gallon (6.9 Lb)
Cost of Fuel per 345 Lb, Evap. F and A 212 Deg.

CHART SHOWING COMPARATIVE COAL AND OIL FUEL COSTS, WITH A GIVEN HEAT VALUE

shown were simply every-day observations in the plant with no attempt to make "test" showings. Rather the plain every-day results as they were in the plant were used, for that is what the owner really pays for. Therefore there was no special preparation for results other than to change over at the right time from coal to oil fuel and back again.

From my observation the comparison of resulting costs is about what to expect in the average factory plant in the country, where the fireroom force is small.

In the plant where the comparisons were made, there was hand firing for coal, with equipment for mechanically storing the coal in bunkers and placing it on the floor for the fireman, and the ashes were removed mechanically.

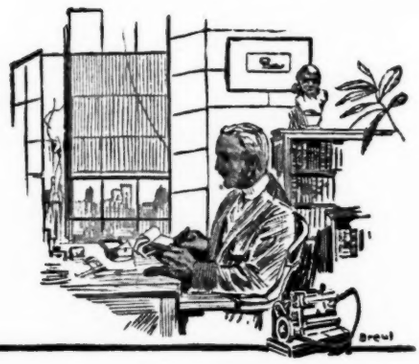
To read the chart for comparison of any two fuels, take the cost of fuel oil per gallon offered for a start and find this cost in cents on the right side of the chart. Follow across the chart from this point until you reach the intersection with the "Oil Cost" line of the chart. From this point of intersection follow vertically upward until reaching the point of intersection with the "Coal Cost" line and thence over to the left side of chart, where you will find the price per ton of coal equal to the cost of oil fuel offered. One example is worked out in dotted lines on the chart, where oil at 8 cents per gal. is shown to be equal to coal at $16 per ton.

All factors entering into the cost of either fuel delivered to the boiler must be considered when comparing. HUBERT E. COLLINS.

Utica, N. Y.

[These fuels cannot be justly compared on a basis of cost only. For the saving in decreased labor, saving in the cost of handling ash and the storing of the fuel and the increase in capacity obtainable are in many cases the deciding factors.—Editor.]

QUESTIONS AND ANSWERS



Acidity of Lubricating Oil

What is the cause of acidity in lubricating oil and how may the presence of acid be detected? P. L.

In compounded oils there will be found more or less fatty acids. These are not active in attacking metal and hence in this respect are harmless. However, they tend to form emulsions if water is present, and in the presence of a small amount of moisture they may cause corrosion.

Greases, such as used to lubricate bearings, almost always show some degree of acidity, although no corrosion will occur unless moisture has been present. It should be understood that fatty acids never are as dangerous as mineral acids. In the refining of lubricating oils, the oil is washed with sulphuric acid. The oil then is treated with an alkali and subsequently washed with water to remove the alkali and it is only seldom if ever that an oil put out by a reputable refiner carries any hurtful quantity of mineral acids.

A general test for presence of acid is to apply a few drops to blue litmus paper, which has the property of changing to a reddish color for the application of an acid. To obtain the reaction on litmus paper, it is customary to moisten the paper with water before applying the oil, and the water thus used may be so alkaline as to neutralize the acid in the solutions. A surer test for acid is to place a small quantity of the oil on a freshly polished brass surface, and if acid is present it will etch the brass in about 36 hours.

Highest Theoretical Vacuum Under Stated Conditions

The vacuum gage on our jet condenser shows 27.8 in. vacuum with the barometer at 29.4 in. and the temperature of the discharge water is 80 deg. What would be the highest theoretical vacuum obtainable under the conditions? R. C. W.

The pressure of steam in the condenser would be that corresponding to the temperature at which the steam is condensed. Assuming that temperature to be identical with the temperature of the discharge water, namely, 80 deg. F.—the pressure as given in Marks and Davis' Steam Tables would be 0.505 lb. per sq.in. absolute, which is equal to 1,029 inches of mercury column pressure.

Hence, neglecting the presence of air in the condenser, if the barometric pressure of the atmosphere is 29.4 in. of mercury column pressure, the highest theoretical vacuum obtainable with condensation taking place at 80 deg. F. would be 29.4 — 1.029 = 28.371 in.; and a vacuum of 27.8 would be 28.371 — 27.8 = 0.57 in. less than the highest vacuum theoretically obtainable.

Loss of Vacuum in Mixed-Pressure Turbine

We have recently placed in operation a mixed-pressure impulse turbine which uses exhaust steam from two non-condensing Corliss engines. Operation has been thoroughly satisfactory until a short time ago, when trouble developed due to loss of vacuum. On several occasions when the turbine load required more than the available supply of low-pressure steam and it was necessary for the valve gear to open up high-pressure valves, the vacuum suddenly failed. We have not been able to find any air leaks. Where should we look for trouble? R. N. G.

When the turbine cuts over on high-pressure steam, there is a tendency to produce a light vacuum in the low-pressure header. Flow valves are usually installed for preventing such a vacuum and maintain a pressure above atmosphere in this header. If no flow valve is installed, you will probably get air in through drains open to atmosphere, if there are any. If the drains are protected by traps or check valves, air is sometimes received through the atmospheric relief valve on account of sluggish action or sticking; such a valve sometimes rises to relieve back pressure and then does not close quickly enough when the pressure falls below atmosphere, thus admitting a large amount of air that destroys the vacuum.

Place a compound vacuum pressure gage on the exhaust line to see how this pressure is maintained. The flow valve may need adjustment, but if none is installed, make sure that the atmospheric relief valve works freely and that low-pressure header drains are protected from air. In the absence of a flow valve, it is sometimes advisable to throttle by means of the hand valve controlling the supply of low-pressure steam to the turbine, in order to maintain the low-pressure header above atmospheric pressure.

Heating Feed Water with Exhaust of Small Turbine

We use a 20-hp. low-pressure turbine that is supplied with exhaust steam through a 2-in. steam line from our shop engine. If the turbine is supplied with live steam of 100 to 120 lb. gage pressure and exhaust against atmospheric pressure, would the exhaust from the turbine be sufficient for heating feed water from 50 to 210 deg. F., required for two water-tube boilers, each 3,000 sq.ft. of heating surface, generating steam at 120 lb. gage pressure with 90 deg. superheating, when the boilers are operated at 150 per cent rating? D. E. C.

The quantity of feed water that could be heated would depend on the amount of turbine exhaust that would be available. Assuming that the turbine would

develop 20 hp., and the steam consumption when supplied with live steam and operated non-condensing against atmospheric pressure would be 60 lb. of steam per horsepower-hour, or 20 × 60 = 1,200 lb. of steam per hour; also allowing that 20 per cent of the exhaust would be discharged as drips or lost to the atmosphere, there would be 80 per cent of 1,200 = 960 lb. of exhaust per hour available for heating the feed water.

Each pound of exhaust, thus available for heating the feed water, would be capable of imparting the latent heat of evaporation at atmospheric pressure, or 970.4 B.t.u., which would be capable of heating 970.4 ÷ (210 — 50) = 6.065 lb. of the cold feed water, and in addition to the pound of condensate contributed, each pound of condensate in cooling from 212 deg. F. to 210 deg. F. would part with 2 B.t.u. and would heat 2 ÷ 160 = 0.012 lb. of the feed water. Hence the total feed water available at 210 deg. F. would be (6.065 + 1 + 0.012) × 960 = 6,794 lb. per hour.

Boiler capacity at normal rating usually is based on evaporation equivalent to 34.5 lb. of water from and at 212 deg. F. per 10 sq.ft. of water-heating surface per hour, or 3.45 lb. per sq.ft. The heat contained per pound (weight) of steam at 120 lb. gage, or 135 lb. absolute, without any superheating, is 1,191.6 B.t.u. Hence with the feed-water temperature 210 deg. F., the factor of equivalent evaporation from and at 212 deg. F. would be (1,191.6 + 32 — 210) ÷ 970.4 = 1.0445, and for each square foot of heating surface with the boilers forced to 150 per cent rating, the required quantity of feed water would be (3.45 × 1.5) ÷ 1.0445 = 4.954 lb. per sq.ft. of heating surface and 3,000 × 3 = 9,000 sq.ft. of boiler-heating surface, forced to 150 per cent of rating, would require 4.954 × 9,000 = 44,586 lb. of feed water per hour. Therefore the exhaust from the 20-hp. turbine operating with the assumed live-steam consumption would be sufficient for heating and furnishing at 210 deg. F., only (6,794 × 100) ÷ 44,586 = about 15 per cent of the quantity of feed water that would be required by the boilers.

Operation of an Engine Overspeed Stop

How does a Monarch electric over-speed stop for a steam engine operate? J. K.

There are a number of types of this engine stop, but an explanation of the operation of one should make it

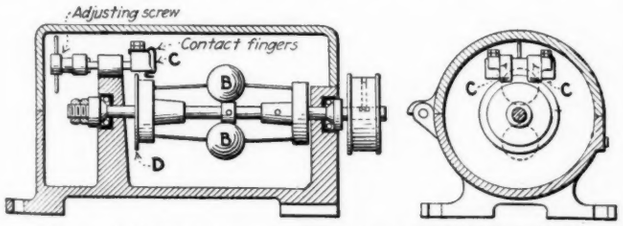


FIG. 1—GOVERNOR FOR ENGINE AUTOMATIC STOP

easy to understand how the others work. The stop consists of two parts, a governor and a valve-closing device. The governor, Fig. 1, is mounted on the engine's bedplate and is belted to the crankshaft and revolves at four times the speed of the shaft. When the engine overspeeds, the flyballs *B* pull the disk *D* up against contacts *C*, thus closing the circuit to magnet coil *M* on the closing mechanism, Fig. 2.

The closing device consists of a drum *D* on which is wound a cable that suspends a weight. This drum is connected to the throttle valve by a chain or gear *G*. Mounted on the drum shaft is ratchet *R* in which pawl *A* engages to prevent the drum from turning when the cable is wound upon it. When the magnet coil *M* is energized, it releases pawl *A* from ratchet wheel *R* and allows the drum to turn, due to the weight attached to the end of the cable, and closes the throttle valve. The right-hand end of the drum shaft is screw-threaded.

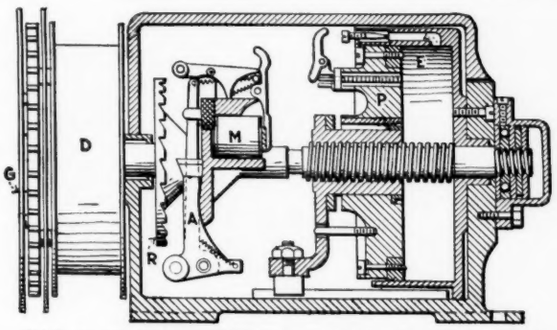


FIG. 2—THROTTLE-VALVE-CLOSING MECHANISM

On the screw is mounted a piston *P* of a dash pot. This dashpot is to prevent the throttle valve from being jammed shut. When the drum is first released, the weight causes it to revolve rapidly and the valve starts to close quickly. As the drum shaft turns, piston *P* is pushed into the dashpot and the air is forced out through passage *E*. When the piston passes the opening to passage *E*, the remaining air is intrapped in the cylinder and can escape only as it leaks by the piston. This action gradually slows up the speed of drum *D* and allows the throttle valve to be seated easily.

What Caused Electric Shock from Whistle Wire?

Above our plant there is run a 220-volt line that is about 30 ft. away from the whistle. When a man blows the whistle and the wind is in a direction to carry the steam around these wires, he gets a severe shock if he is not careful. The wires are insulated. Is it possible for the current to travel along the steam down through the whistle wire, and the man to the ground?

J. H. A.

It requires such a small current to give an unpleasant shock (not a severe shock) that it can flow through almost anything. Although the power wires may have been insulated when installed, there are excellent chances that whatever covering may be on them now is a fairly good conductor from being impregnated with carbon dust and other conducting substances from the atmosphere. When the whistle is first blown, a cloud of wet vapor is created and could act as a conductor for a very small current that would give a slight shock to anyone pulling the whistle wire. The surface of the skin of anyone's hands working around a power plant is made a fairly good conductor, due to being smeared with carbon dust and other conducting substances, and this would improve the conditions for receiving a shock. A case in mind is that where a shock was obtained on a rainy night from the bottom spike in a wooden electric-light pole. The light was about 35 ft. above the spike and sufficient current was leaking down the pole to give a slight shock to anyone touching a spike in the pole about 4 ft. from the ground. In case of the whistle there is the possibility of the shock being due to static electricity generated by the steam blowing through the whistle. The best solution to the problem is to replace the wire on the whistle with a cord.

Low-Pressure Refrigerants*

BY HARRY D. EDWARDS,
Consulting Engineer

THE development of the small refrigerating machine has brought to the front the merits and disadvantages of practically all the known low-pressure refrigerant gases, and the hope that the ideal chemical might be found has caused a study of many substances heretofore not considered.

The non-existence of necessary data or the lack of foresight in obtaining existing information about refrigerants before using them has caused bitter disappointmnts in the results expected. The choice of a chemical for the small automatic refrigerating unit requires a close study of the chemical as well as the physical properties and necessitates a special study of the lubrication problem.

While as yet, at least in this country, low-pressure refrigerants have not been used for large installations, it seems quite probable that for some purposes, particularly when low temperatures are not required, they might be used, especially those having the lower boiling points.

The following chemicals have been considered—some have been used experimentally and some are in daily use. They are given in the order of their boiling points: Ethyl alcohol; carbon tetrachloride; ethyl iodide; hexane; methyl alcohol; carbon disulphide; ethyl bromide; pentane; ether (ethyl); ethyl chloride; butane; sulphur dioxide; methyl chloride.

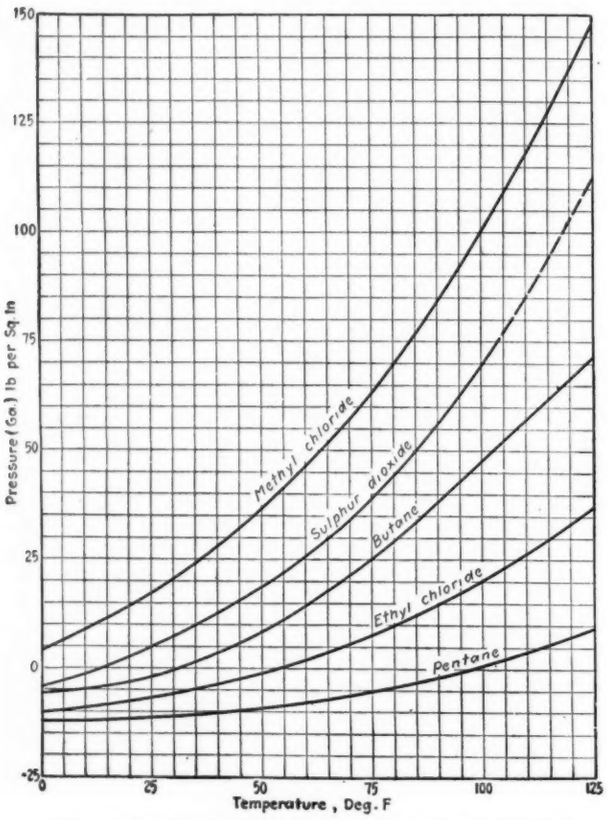


FIG. 1—BOILING TEMPERATURES OF IMPORTANT REFRIGERANTS

Very little is known about several of those mentioned. Hexane, pentane and butane are gases of the paraffin series, while ethyl alcohol, ethyl iodide, methyl alcohol, ethyl bromide, ether, ethyl chloride and methyl chloride are a combination of the elements of the paraffine series with bromine, chlorine or oxygen.

*Paper read before the annual meeting, National Association of Practical Refrigerating Engineers, St. Louis, Mo., Nov. 2-4, 1922.

The methyl and ethyl bromides are colorless liquids with a sweetish taste and a burning after-taste effect. Their smell resembles that of chloroform and their vapors have anesthetic properties. Each burns with a green flame evolving hydro-bromic acid.

The ethyl and methyl chlorides likewise have ethereal odors and burn with a greenish flame in air. In a combustion of both methyl and ethyl chloride in air under certain conditions phosgene gas may be formed. One part of water

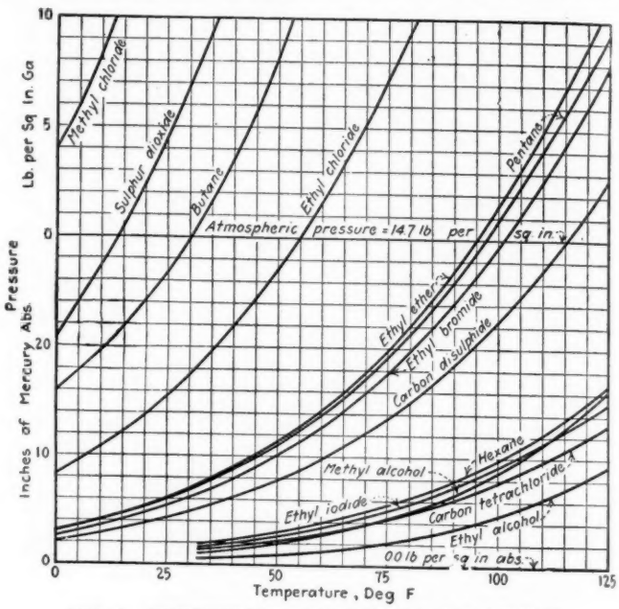


FIG. 2—PRESSURE-TEMPERATURE RELATIONS OF REFRIGERANTS

dissolves four volumes of methyl chloride and probably about equal volumes of ethyl chloride. All the bromides, chlorides and paraffin gases in the liquid state are solvent of fats.

Carbon tetrachloride is non-inflammable; it yields chlorine and lower chlorides of carbon on passing through a red-hot tube. In its physiological action carbon tetrachloride strongly resembles chloroform. The inflammability of all

TABLE I—HEXANE VAPOR

Temp., Deg. F.	Abs. Press. Lb. per Sq.In.	Heat of Vaporization	Spec. Vol. Cu.Ft. per Lb.
0	0.246	.....	.....
10	0.393	.....	.....
20	0.59	164.5	55.0
30	0.836	163.0	43.0
40	1.105	161.5	34.5
50	1.475	160.0	28.2
60	1.92	158.5	23.5
70	2.46	157.0	19.5
80	3.10	155.5	16.3
90	3.88	154.0	13.8
100	4.82	152.5	11.8
110	6.00	151.0	10.2
120	7.92	149.0	8.8

the combustible compounds is decreased as the bromide and chloride quantities increase; carbon disulphide is very inflammable.

Sulphur dioxide is used for many purposes other than for refrigeration. In the liquid state it is colorless and its vapors possess the smell of burning sulphur. It is extremely soluble in water. The solution of the gas has a strongly acid reaction, save when perfectly dry. Sulphur dioxide is poisonous; one part in 2,500 in the air causes difficulty of breathing.

The fact that thousands of small refrigerating machines using sulphur dioxide are in daily service, and the fact that their operation has been practically without accident, should

be sufficient evidence of the lack of an asphyxiation or leakage hazard from a properly designed machine.

Hexane, pentane and butane are colorless liquids. Their gases have a slightly ethereal odor; their vapors are slightly anesthetic. They burn in air with CO_2, water and nitrogen as the products of combustion. They are practically insoluble in water.

It is well known that where the chemical has to be used repeatedly as in the small household machine, it is difficult with existing designs to keep the refrigerant from leaking around the stuffing box which is generally very close to a bearing. During the slow leakage of the gas, moisture in the atmosphere surrounding the metal parts by which the refrigerant is passing, slowly combines with either the chlorine, bromine or sulphur elements, and forms hydrochloric, hydrobromic or sulphuric acids respectively. These acids frequently attack the metal parts, particularly the driving shaft at the edge of the stuffing box, and gradually cause deterioration of the bearings and final ruin of the compressing unit.

The least trace of moisture in the refrigerant or in the lubricant causes a formation of acid. This is particularly

TABLE II—PENTANE VAPOR

Temp., Deg. F.	Abs. Press. Lb. per Sq.In.	Heat of Vaporization	Spec. Vol. Cu.Ft. per Lb.
0	1.425	169.5	37.0
10	1.94	168.0	30.0
20	2.58	166.0	23.6
30	3.34	164.5	19.0
40	4.33	163.0	15.3
50	5.46	161.5	12.5
60	6.81	160.0	10.4
70	8.45	158.0	8.65
80	10.47	155.0	7.25
90	12.87	154.0	6.10
100	15.70	152.0	5.14
110	18.90	150.0	4.30
120	22.50	148.0	3.62

so in the case of sulphur dioxide where it has been found advisable even especially to dry the lubricating oil before inserting it into the compression unit.

Where glycerin is used with ethyl or methyl chlorides, it forms some sort of a combination with the gas. A deposit is formed upon the cylinder walls sufficient to seize the piston if the compressor is allowed to stand for a lengthy period. Whether this is due to impure chemical, impure lubricant or moisture, does not seem to be known at the present time.

Another consideration of vital importance in connection with the lubrication problem when using these gases, is whether or not they are solvents of the lubricating oil and whether they are heavier or lighter than the lubricant. It can be assumed that all methyl and ethyl combinations with gases of the paraffin series are solvents of the lubricants. Carbon tetrachloride will also dissolve oils generally used. The gases of the paraffin series—pentane and butane—are likewise solvents. Sulphur dioxide, carbon tetrachloride, ethyl iodide and ethyl bromide have a density greater than that of the usual lubricating oils.

Numerous vegetable and mineral oils of special qualities have been suggested and tried in connection with the solvents, and experience has seemed to prove that glycerin or something of this nature is the only suitable lubricant where it must be used repeatedly. Recently, the development of the glycols has given a lubricating product having the same

TABLE III—BUTANE VAPOR

Temp., Deg. F.	Abs. Press. Lb. per Sq.In.	Heat of Vaporization	Spec. Vol. Cu.Ft. per Lb. By Comparison
0	7.9	174.0	11.0
10	9.7	171.9	9.0
20	11.9	169.7	7.5
30	14.63	167.5	6.3
40	18.25	165.5	5.4
50	23 0	162.7	4.7
60	28.2	160.0	4.1
70	35.2	157.5	3.7
80	44.2	155.0	3.2
90	52.7	151.8	2.8
100	62.45	148.5	2.6
110	72.1	145.2	2.3
120	86.4	142.0	2.1

characteristics as glycerin. Glycol, due to its lower cold test, permits much lower temperatures without the congealing trouble which has been experienced with glycerin and which places such excessive starting loads upon the smaller motors used in the household plants. The lubricating qualities of the glycol have been increased by the addition of deflocculated graphite.

Extreme care is required in handling both the glycerins and the glycols, as they are hydroscopic and will absorb moisture very rapidly if exposed to the air. This difficulty, of course, is not present when they are used with pentane or butane, as these gases will not combine with water.

It does not necessarily follow that the lubricating properties of the ordinary oils have been destroyed by those refrigerants which are solvents of fats. It is much more probable that the lubricating oils are simply diluted with the refrigerant. This is known to be the case when hydrocarbons are used and is evidenced by the fact that in the commercial compressors using these refrigerants, the regular lubricating oil used with ammonia has been entirely satisfactory.

In the small automatic household machine regular lubricating oil should be used only with sulphur dioxide, in which case it must be free from moisture. Moisture should be guarded against when using all these refrigerants, except the pure hydro-carbons. If it is necessary to separate the lubricant from the refrigerant, consideration must be given to which is the heavier and the difference in densities should be as great as possible.

The question of fire hazard or asphyxiation is of very little importance in the small machine; the quantity of

TABLE IV—PROPERTIES OF VARIOUS REFRIGERATORS

		Ethyl Alcohol	Carbon Tetrachloride	Ethyl Iodide	Hexane	Methyl Alcohol	Carbon Disulphide	Ethyl Bromide	Pentane	Ether-(Ethyl)	Ethyl Chloride	Butane	Sulphur Dioxide	Methyl Chloride
Column number		1	2	3	4	5	6	7	8	9	10	11	12	13
Chemical symbol		C_2H_6O	CCl_4	C_2H_5I	C_6H_{14}	CH_4O	CS_2	C_2H_5Br	C_5H_{10}	$C_4H_{10}O$	C_2H_5Cl	C_5H_{12}	SO_2	CH_3Cl
Molecular weight		46.06	153.84	155.97	86.15	32.04	76.13	108.97	72.13	74.10	64.50	58.10	64.06	50.47
Gas constant		41.44	.....	.....	.....	72.62	21.16	.....	.....	10.57	.....	26.82	24.10	30.59
Critical temperature,	Deg. C	.....	.....	.....	.....	.....	.....	.....	.....	.....	183	155	155	143
	Deg. F.	.....	.....	.....	.....	.....	.....	.....	.....	.....	360	311	311	289
Critical pressure-atmos.		.....	44.9	.....	.....	.....	.....	.....	.....	.....	54	37	79	70
Boiling point,	Deg. C.	78.3	76.7	77.3	69.0	64.6	46.2	38.4	36.4	34.5	12.5	0.3	—10.8	—23.7
	Deg. F.	173.0	170.0	160.0	156.0	148.0	115.0	101.0	97.0	94.0	54.5	32.5	+12.6	—10.6
Melting point,	Deg. C.	—114.2	—22.9	—110.9	—94.0	—94.9	—111.6	—115.5	—130.8	—116.2	—142.5	—135.0	—76.0	—103°6
	Deg. F.	—173.6	—9.4	—167.5	—137.1	—138.8	—169.0	—176.0	—203.5	—177.1	—224.5	—211.0	—104.8	—154.5
Density of liquid at 0, deg. C, Water = 1		0.78	1.58	1.92	0.66	0.80	1.29	1.44	0.65	0.72	0.92	0.60	1.44	0.95
Spec. vol. of gas at 32 deg. F.		.....	52.6	.....	.....	.....	28.3	.....	.....	20.1	8.8	.....	3.40	2.67
Cu.ft. per lb. at 0 Deg. F.		.....	.....	.....	.....	.....	53.7	.....	.....	38.0	18.5	.....	7.22	5.05
Ratio of spec. heats		1.133	.....	.....	.....	1.256	1.205	.....	.....	1.024	.....	1.108	1.40	1.20
Sp. ht. at const. press.		.453	.....	.....	.....	.458	.160	.....	.....	.428	.274	.351	.154	.24
Vapor tension at 80 deg. F.	Lb. absolute	1.3	2.40	2.9	3.2	2.5	7.30	9.8	10.6	10.9	24.2	36.2	59.9	87.0
	Gage press.	27.4	25.0	24.2	23.7	25.0	14.5	10.3	8.7	7.6	.....	.....	.....	.....
Suction pressure at 32 deg. F.	Lb. absolute	0.3	0.65	0.8	0.9	0.5	2.5	3.25	3.7	3.65	9.10	14.6	22.9	36.6
	Inches of vac.	29.5	28.7	28.4	28.2	29.0	25.0	23.5	22.8	22.7	11.2	0.2	.....	.....
	Gage press.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	8.2	21.9
Ratio of compression		4.3	3.7	3.6	3.5	5.0	* 2.94	2.68	2.87	2.98	2.66	2.48	2.62	2.38
Heat of vaporization at 32 deg. F.—B.t.u.'s per lb.		.....	93.6	.....	162.0	.....	162.0	.....	164.0	169.2	165.5	167.0	163.6	174.6
Heat of liquid above 32 deg. F.		.....	9.8	.....	14.4	.....	11.7	.....	14.4	26.4	20.5	14.4	24.5	22.5
Net cooling effect per cu.ft. of cyl. displacement		.....	83.8	.....	147.6	.....	150.3	.....	149.6	142.8	145.0	152.6	139.1	152.1

liquid varies from one to a very few pounds. Considering the question of leakage that might give an explosive mixture, we find that such machines are so well built and guarded with safeties and the pressures are so low that a rupture due to pressure is inconceivable.

The small machine is so constructed as to hold its charge indefinitely, and unless subject to a fire of sufficient intensity to have caused the departure of all persons in the vicinity, the rate of leakage would be so slow that the ordinary change of air in the room would be sufficient to remove all possible hazard. Should the machine rupture through external heat, the liquid contents would be in a gaseous form and would immediately be ignited and would burn. The total heat results of such a burning would be insignificant in comparison with those following the breaking of a gas line under like conditions.

Usually, the first consideration in selecting a refrigerating medium is the vapor tension of the gas at the compressor suction, in order to give the required temperature.

The lower the discharge pressure the less will be the leakage of gas from within the unit, and the nearer the suction pressure is to that of the atmosphere the less the possibility of the air without becoming mixed with the refrigerant.

The first five refrigerants which are often subject to discussions as possible refrigerating mediums have such low tensions that their cycle would be entirely below atmospheric pressure. To reach temperatures appreciably below the average obtainable with cooling water, the unit would have to work under such high suction vacuums that the present compressors, or better stated, vacuum pumps, would not be commercially feasible.

The next four refrigerants—carbon disulphide, ethyl bromide, pentane and ethyl ether—might be used likewise under vacuum conditions where it is desired to cool air for ventilating purposes, etc. The vapor tensions of these on the suction side would be within the range of the commercial vacuum pump. The volumes that would have to be handled under these conditions would be so large that an appreciable amount of refrigeration could not be produced in the ordinary piston or rotary type compressors. It is possible, of course, to produce the necessary quantity of refrigeration by using the turbo-compressor, which is already being utilized for this purpose.

Proceeding further down the list previously given, we find the other gases used more or less extensively at the present time, the ethyl chloride and sulphur dioxide machines predominating. Better appreciation of the causes of some of the troubles in the small unit has led those entering this field to consider other chemicals, and has also caused the development of other chemicals that might be more suitable. Two new developments are the commercial production of butane and methyl chloride.

Butane has long been known to be a good refrigerant, and it is only recently that it has been commercially obtainable in the pure state. Methyl chloride is very similar to ethyl chloride with the exception that its working ranges of pressures are higher than those of the former.

The latent heat, the ratio of compression, etc., are all important points to be considered in the selection of one of these refrigerants. The net refrigeration per pound varies little, and in most cases any advantage of one over another is of minor importance if any mechanical difficulties are involved. From the information previously given, it would seem that few if any of the refrigeration mediums considered, will ever be of any value to the refrigeration engineer in the making of ice or general cold-storage work. However, development in the art of refrigeration is proceeding so rapidly that it is not inconceivable that methyl chloride and butane will eventually obtain an important place in refrigeration practice, outside of the small unit. Methyl chloride has a higher condenser pressure and gives lower temperatures with a positive suction pressure than can be obtained with the other refrigerants considered, and many of the difficulties that are encountered in small machines with its use, would probably be of little importance in the large commercial installation.

Where temperatures no lower than 33 deg. are required, butane offers many possibilities. Under these conditions the suction pressure would be practically atmospheric. It could be compressed in a standard 50-lb. air compressor. All the pipe and fittings would be standard. The discharge pressures would be so low that there would be no difficulty in getting an absolutely tight system. Any materials of construction might be used. In making changes in the system or in case of an accident, no helmets or special appliances are needed when making repairs. The system would be entirely safe from within and entirely safe from without if installed with the usual safeguards about open flames which are recognized as essential in the regular ammonia installations. The cost of such a system should be materially less than that of the present ammonia installations. The volume of the butane compressor would be about three times that of an ammonia compressor to give equal amounts of refrigeration.

Interpretations of the A.S.M.E. Boiler Code

Requests for interpretations of the Boiler Code are acted upon by the Boiler Committee, their formulated replies being submitted to the Council of the American Society of Mechanical Engineers. The inquiries and replies are published from time to time in *Power*, with such explanatory comments and illustrations as seem advisable for a clear understanding of the interpretations on the part of engineers in general. The last group of interpretations published in *Power* was in the issue of August 22, 1922.

Case No. 406—Inquiry: Will a form of forged steel boiler nozzle with flange pressed hot over the end neck of the nozzle which is compressed or forged into a recess or groove in the flange conform to the requirements of the Code?

Reply: It is the opinion of the Committee that this method of forming a steam outlet connection meets the requirements of the Rules in the Boiler Code.

Case No. 407—Inquiry: Is it permissible under the Rules of the Code for Boilers of Locomotives to mark a safety valve A. S. M. E. Std., when it is not fitted with a lifting device, whereas Par. 282 of the Power Boiler Section of the Code requires such a lifting device?

Reply: Inasmuch as Par. 282 of the Power Boiler Section of the Code requires a lifting device and there is no similar requirement in the section of the Code for Boilers of Locomotives, it is the opinion of the committee that safety valves for use in stationary service under the Power Boiler Rules must be fitted with a lifting device and those intended for use on boilers of locomotives need not have such a lifting device, and that it is proper in each case to mark the safety valve A. S. M. E. Std.

Par. 282 reads as follows: "To insure the valve being free each safety valve shall have a substantial lifting device by which the valve may be raised from its seat at least $\frac{1}{16}$ in. when there is no pressure on the boiler."

Case No. 395—(Annulled).

Case No. 397 (Reopened)—Inquiry: Was it the intent in Par. 199, to permit a value of 175 for C where copper washers were used as described in the definition for C?

Reply: It is the opinion of the committee that the washers should be of steel to permit the use of 175 for C. Copper washers may be used provided the value of C is taken the same as if no washer were used.

According to Par. 199 the maximum allowable working pressure for various thicknesses of braced and stayed flat plates, and those which by the rules require staying as flat surfaces with braces or staybolts of uniform diameter symmetrically spaced, shall be calculated by the formula: $P = C \times \frac{T^2}{p^2}$, where P = maximum allowable working pressure, pounds per square inch; T = thickness of plate in sixteenths of an inch, p = maximum pitch measured between straight lines passing through the centers of the staybolts in the different rows, which lines may be horizontal, vertical or inclined; and C is a constant ranging from 112 to 175, the exact value depending upon the method by which the stay is fastened to the plate. For instance, the value of C is given as 112 for stays screwed through plates not over $\frac{7}{16}$ in. thick with ends riveted over, while it is 175 for stays fitted with inside and outside nuts and outside washers, where the diameter of washers is not less than $0.4p$., and thickness not less than T. According to this ruling the value of C with copper washers should be 135 for stays screwed through the plate and fitted with an outside nut and washer only.

Autogenous Welding of Unfired Pressure Vessels

At the regular November meeting of the Chicago section of the American Society of Mechanical Engineers Harry Sloan, president of the American Society of Refrigerating Engineers, delivered an interesting address on "The Autogenous Welding of Unfired Pressure Vessels." Going back to the early part of 1920, when the council of the A.S.M.E. requested the American Society of Refrigerating Engineers and the American Welding Society to appoint conference committees to co-operate with a subcommittee of the Boiler Code committee in formulating that part of the Boiler Code dealing with unfired pressure vessels, Mr. Sloan reviewed briefly the progress of the work and the present status of this section of the Code.

During 1921 the conference committees had submitted material from which the Boiler Code committee prepared a tentative code, which was printed and distributed broadly in order that a public hearing might be called for Dec. 5 of that year. If adopted, this code would have eliminated entirely the use of autogenous welding. During the hearing the different manufacturers of refrigerating equipment presented written reports of tests made by disinterested investigators, and in addition the committee requested that written suggestions be sent in after the meeting. At the A.S.M.E. spring meeting in Atlanta a session was provided for the discussion of this topic, and from the information gained the code was again revised. To the discouragement of the refrigerating field practically no consideration had been given the large amount of data presented, as the latest revision still practically eliminated the use of welding in unfired pressure vessels. Another revision, however, has been made recently and in its present form, as printed in the November number of *Mechanical Engineering*, the Code makes the first concession of any description toward welded vessels, but still entirely eliminates longitudinal seams.

The urgent need for such a code at the present time was pointed out by the speaker. There was a tendency for different states and cities to set forth regulations for these vessels which they consider will make them safe. These rules for the most part are framed by men having little knowledge of these matters and in many cases not guided by proper scientific data. Such sectional ordinances would result in unbearable confusion to the manufacturers of such vessels. Through the prestige gained from its Boiler Code, the American Society of Mechanical Engineers was undoubtedly the right organization to create a code that might be used universally.

To indicate why the refrigerating industry was so vitally interested, Mr. Sloan pointed out that in the one application of mechanical refrigeration, the manufacture of ice, which ranks ninth in the industries of the United States, it was estimated that equipment alone represented an investment of $750,000,000. If all the refrigerating equipment in the United States were operated at full capacity, the refrigerating effect would probably be equivalent to the melting of 1,000,000 tons of ice a day.

The welding of refrigerating equipment has boomed the industry, and, conversely, the industry has gone far toward developing the art of welding to its present state. One of the main requisites of the closed refrigerating system is absolute tightness and nothing insures freedom from all leaks so well as do the welded containers, headers, etc., now in general use. There had been accidents, said the speaker, but when the conditions universally prevailing until a few years ago, and still prevailing throughout the greater part of the country, were considered, the wonder was that there had been so few. Welded containers were put in closed systems without relief valves or safety appliances of any description. As a comparison, the number of boiler explosions should be considered. At the same time it should be remembered that from the outset boilers have been provided with safety valves.

The American Society of Refrigerating Engineers has been engaged for several years in formulating a safety code, and at the next annual meeting the sections relating to ammonia and other agents in common use for some time are to be presented for action. Universal adoption of this code should further reduce the liability of accidents.

To overcome objections to the code, methods must be developed for properly specifying the materials and testing the finished products. In this connection the speaker referred to the tests shortly to be made by the Bureau of Standards, to which a number of manufacturers have contributed tanks to be tested to destruction. These are all 24 in. in diameter by 6 ft. long and are made of ⅜-in. material. There are about seventy of these tanks, some being welded poorly with intention. It was the speaker's hope that this investigation would develop simple methods of testing these vessels that would always detect unsafe containers.

After the paper a number of slides were presented to show different constructions such as tanks with different designs of head, manifolds or headers with numerous welded outlets, and vessels that it would have been difficult to duplicate through the use of fittings. In other views the location of ruptures in tanks tested to destruction were shown and it was pointed out that failures occurred at pressures ranging from 2,400 to 3,700 lb. per sq. in., as compared to an allowable working pressure of 250 lb. per square inch.

The discussion turned to the impracticability of using castings to replace welded steel vessels on account of the lower density of the metal and the probability of leaks developing. Other points considered were electric versus gas welding, the human element, the possibility of determining the quality of a weld by its electric conductivity and methods for shop testing of the weld to determine its quality, such as the application of hydraulic tests and hammering at the same time to show up pin-holes.

Navy Predicts Water-Tube Boilers on All Passenger Ships

The ultimate equipment of all passenger ships with water-tube boilers because of the greater element of safety, as well as the advantages of weight and quick steaming of this type over the Scotch boilers, is predicted by engineering experts of the Navy Department.

While the preference of the merchant service for the Scotch boiler is recognized by Navy officers, they attribute this to the constantly changing personnel, particularly in freighters. Proper handling of the water-tube boilers requires more experience than is the case with the Scotch type. Officials of the United States Shipping Board, who have found that, all other factors being equal, they have been able to sell a ship equipped with Scotch boilers more readily than one equipped with water-tube boilers, recently stated the same opinion that the prejudice was due to personnel.

The Navy uses water-tube boilers because of the advantages of quick steaming and the necessities of forced draft, this type rendering a flexibility of service not possible with Scotch boilers. But the element of superior safety in the water-tube boilers has been demonstrated on repeated occasions in actual operative experience with the Navy, so that now many engineering officers are of the opinion that it will not be far in the future until water-tubes will be made a legal requirement for passenger vessels. If a tube explodes in a water-tube boiler, the boiler may be wrecked but the damage is local, these officers point out, while an explosion in a Scotch type is more likely to wreck the ship.

Much of the trouble reported in operating water-tube boilers is attributed by naval officers to a direct intake of sea-water, which corrodes the tubes and which may be charged to ignorance of the men in charge.

Power production records were again broken in October. The average daily production of electricity by public utilities was 139,100,000 kw.-hr., over 3 per cent greater than the September record and nearly 9 per cent greater than the first record, established in June.

News in the Field of Power

Work on Wilson Dam Going Ahead Rapidly

The low stage of the Tennessee River, together with ideal weather conditions, have aided in speeding up the work on the gigantic Wilson Dam at Muscle Shoals. Work on this dam was resumed by the government on Aug. 15, and the dam is now about one-third completed. About 1,400 men are employed, seventy-five per cent of these living on the grounds. No labor shortage has been experienced. Officials say that with good weather and favorable working conditions the dam may be completed within two years.

When completed the Wilson Dam will be 4,500 ft. in length overall, with a spillway 2,900 ft. long, while the power house will be about 1,200 ft. long and about 30 ft. high. The dam crest will be about 80 ft. above the river bed, which with gates 18 ft. high gives a head of 98 ft. The power plant, located on the Colbert County side of the river, will have four 30,000-hp. and fourteen 36,000-hp. turbo-generators. On the north side of the river there will be constructed two locks, 60 ft. wide and 350 ft. long. These will afford navigation. The dam will be surmounted by a roadway 40 ft. wide.

What is said to be the largest concrete mixing plant in the world is located on Jackson Island, near the dam. This plant crushes and mixes 4 cu.yd. of concrete every three minutes, or 1,900 cu.yd. every twenty-four hours.

To Gather Operating Data on Refractories

Desiring to learn the furnace conditions confronting refractory brick in actual service, the Refractories Manufacturers' Association has started an industrial survey among the users of this material.

A questionnaire has been distributed to consumers of refractory brick in the thirteen industries to which the bulk of this material goes. This questionnaire covers temperature and combustion conditions found in the typical furnace, abrasion, slag action, the presence or absence of uncommon furnace gases, spalling conditions, loads, insulation, character of draft, etc. Reports showing the progress of the survey in the different industries will be made as rapidly as the necessary information is obtained. Each report will contain a statement of the more general and possibly typical conditions in each industry, with data relative to conditions that would probably be considered exceptional in that industry.

The survey will consume the better part of two years, and it is hoped that preliminary reports will be made at the end of the first three months, the first half year, and so on until the survey is completed. Every user of refractory brick will derive benefit from the survey, and the association urges that these consumers realize that they will be helping themselves by answering and returning the questionnaires to R. M. Howe, Mellon Institute of Industrial Research, Pittsburgh, Pa.

Fuel Shortage Causes Cut in Power Service

Suspending power service to its industrial patrons for one day a week is the expedient now being resorted to by the Southern Power Company to tide over the present drought. It is probable that five-day service will be continued until the situation is relieved by copious rains on the head-waters of the Catawba and other streams on which the power plants of the Southern Power Company are located. The suspension does not apply to municipalities and other public users of power.

The coal shortage is blamed for this curtailment of service, since the limited coal supply for several weeks during the summer compelled heavy drawing on the reserve supply of water. The water heads have now been pulled down so low that the generating capacity is reduced and there is danger of putting the water plants out of commission unless great care is exercised.

Model Gives Good Idea of Power System

A novel and "live" exhibit was recently staged by the Georgia Railway and Power Co. at the Southeastern Fair, Atlanta, Ga. It consisted of a large relief map, 16 by 20 ft. in size, showing the lakes and power plants of the company in northern Georgia. Real miniature lakes, miniatures of the dams and power stations, replicas of the streams leading into the lakes—even the famous tunnel at Tallulah Falls—were shown with accurate detail.

From Burton Lake, the first of the series, the water was shown flowing over the dam and through the power plant to Lakemont. Thence the stream was traced to the Tallulah Falls power plant, and finally to the Tugaloo River, past the new dam.

From each plant, miniature transmission lines led across the hillsides into the cities and villages of northeast Georgia, where the power was shown set to work in cotton factories, in homes, churches and schools and electric railways.

This exhibit, supplemented with excellent photographs of the different plants, lakes and dams, showed more clearly than any amount of advertising could have done the magnitude of the power company's projects and plants and the service it is rendering Georgia.

Creates Prize Fund for Electric Advance

The creation of a $400,000 fund, known as the Charles A. Coffin Foundation, in honor of the founder of the General Electric Co., has been announced by the company. The income from this fund will be used for encouraging and rewarding meritorious service in the electrical field.

Annually, the foundation committee will award prizes to company employees who have shown unusual ability in their line and to lighting, power and railway companies for improvement in service to the public. Fellowships will be awarded graduate students, and funds will be made available for research work at technical schools and colleges. Eleven thousand dollars will be devoted each year to prizes for the most signal contributions by General Electric employees, executives of the company included.

A gold medal and $1,000 will go each year to the public utility operating company making the greatest contribution toward increasing the advantages of the use of electric light and power, and a similar award will go to the electric railway company rendering similar services.

The company's board of directors has appointed as the "Charles A. Coffin Foundation Committee" the following officers of the company: A. W. Burchard, J. R. Lovejoy, E. W. Rice, Jr., Gerard Swope and O. D. Young.

Mr. Coffin retired in May from the active leadership of the company. He had been identified with the development of the electrical industry since 1882 and was the leader of the General Electric Co. for thirty years.

Water-Power Progress in Wisconsin

Four large water-power developments are in progress in Wisconsin, according to the hydraulic engineer of the State Railroad Commission. The Wisconsin Public Service Company is building a dam and installing hydro-electric equipment at a plant built some years ago by the company. The Big Falls Power Company is constructing a dam on the Flambeau River near Ladysmith. The Wisconsin-Minnesota Light & Power Company is building a reservoir dam on the Chippewa River, where a large quantity of water will be stored and released during times of low flow, although it is not intended to install hydro-electric equipment. The Chippewa Power Company is completing a water-power development at Jim Falls, where the dam is already built. This plant, which will benefit by the Wisconsin-Minnesota company's new dam, will probably sell power in St. Paul and Minneapolis.

Heads Electrical Engineering at Cornell

Paul M. Lincoln, recently appointed director of the electrical engineering college, Cornell University, to succeed Prof. Alexander Gray, deceased, is a man of wide engineering experience. Graduating from Ohio State University in June, 1892, Mr. Lincoln first worked for the Short Electric Co., of Cleveland. In December of that year, he went to Pittsburgh to take up work with Westinghouse. Two and one-half years later he went as electrical superintendent to the Niagara Falls Power Co. This was at the beginning of the modern phase of the water-power development of Niagara Falls. The seven years, from 1895 to 1902, that Mr. Lincoln spent there were, he says, among the most interesting and profitable of his life.

In 1902 Mr. Lincoln returned to the Westinghouse company, in an engineering capacity. For some six or seven years he had charge of the power division. In 1910 he was appointed a general engineer for the company, and remained in that capacity until the date of his resignation in 1919. From 1911 to 1915 Mr. Lincoln acted as the head of the electrical school of the University of Pittsburgh, while still carrying on his work with the Westinghouse company. This gave him a close contact with technical education that will probably be of great service in his new connection.

On Nov. 1, 1919, he took up work with the Lincoln Electric Co., organized by his older brother in 1894. The appointment to his present position at Cornell University followed three years of service with that company.

Mr. Lincoln has for many years taken an active interest in the affairs of the American Institute of Electrical Engineers. For five consecutive years, 1909 to 1914, he served as chairman of the Sections Committee, and in 1914-15 he served as president of the Institute. He brings to his new position a practical engineering experience of nearly thirty years, wide connections in the engineering world, and that balance, tact, sound judgment, optimism and human sympathy well known to all who have come in contact with him.

Buys 1,000 Coal Cars To Avoid Assignments

Rather than interfere with the orderly development of the mines of his company, Thomas H. Watkins, testifying in the assigned-car case, told the Interstate Commerce Commission that recently he had purchased one thousand coal cars. The use of these private cars means a direct loss of $75,000 a year; nevertheless, said Mr. Watkins, it is profitable to use them because it decreases the losses occasioned by the inability of the railroad companies to furnish cars regularly. Mr. Watkins has been one of the outstanding opponents of the assigned-car practice.

E. M. Posten, president of the New York Coal Co. and of the Interstate Coal and Dock Co., evidently impressed the Commission with his contention that the assigning of cars adds no less than one dollar per ton to the cost of all coal because the disturbing effect of assigned cars on labor is one of the principal reasons why mine workers have to be paid a high daily wage.

In answer to questions from the bench, Mr. Posten explained why there is a surplus of coal-mine labor. One of the principal reasons, he said, grows out of the frequent periods of car shortage. During these periods the price of coal goes up to a point where a large number of small mines can be brought into operation. So as to take full advantage of the short time they will have to operate, they offer labor more than the regular scale.

In addition, Mr. Posten made a plea for the storage of coal by all large consumers. He declared it would be profitable to consumers and would do much to stabilize the coal industry. Had the railroads stored all the coal they could in 1921, he said, it would have resulted in large savings to them and might have averted the strike.

Dr. Smith, Governor Marshall and Judge Alschuler, of the President's coal commission, have attended some of the sessions of the hearing and have interrogated witnesses.

Coming Conventions

Kansas Engineering Society; T. M. Averill, secretary, Topeka, Kan. Annual meeting at Topeka, Dec. 14-15.

American Association for the Advancement of Science; L. O. Howard, secretary, Smithsonian Institution, Washington, D. C. Annual meeting at Boston, Dec. 26-30.

American Engineering Council; L. W. Wallace, secretary, 24 Jackson Place, Washington, D. C. Annual meeting at Washington, D. C., Jan. 11-12.

Compressed Gas Manufacturers' Association; John H. Hayes, 120 W. 42d St., New York City. Annual meeting at New York City, Jan. 15.

Marine Engineers' Beneficial Association; George A. Grubb, secretary, Machinists' Bldg., 9th St. and Mount Vernon Place, Washington, D. C. Annual meeting at Washington, Jan. 15-20.

American Society of Civil Engineers, 29 W. 39th St., New York City. Annual meeting at New York City, Jan. 17-18.

Iowa Engineering Society; Lloyd A. Canfield, secretary, 406 Flynn Bldg., Des Moines. Annual meeting at Des Moines, Jan. 23-26.

American Society of Heating and Ventilating Engineers, 29 West 39th St., New York City. Annual meeting: Jan. 23 at New York City, Jan. 24-26 at Washington, D. C.

American Institute of Electrical Engineers, 29 West 39th St., New York City. Mid-winter convention at New York City, Feb. 14-16.

American Institute of Mining and Metallurgical Engineers, 29 West 39th St., New York City. Annual meeting at New York City, Feb. 19-21.

Personals

Leland D. Wood has left Edward C. Brown & Co., engineers, Boston, to become manager of the light and power department of Hudson, Mass.

E. G. Quarnstrom, formerly superintendent of the municipal electric light plant at Madison, S. D., is now with the Union Public Service Co., Canby, Minn.

B. F. Jakobson, for the last three years chief designing engineer for the San Joaquin Light & Power Corp., has opened offices in Fresno, Calif., as a consulting hydraulic and electrical engineer.

H. E. Dalzell, after fifteen years' service in the tropics, is taking an eight months' holiday, prior to taking a position on the east coast of South America in the spring. Mr. Dalzell's most recent position was that of chief mechanical and electrical engineer for the Southern Railway of Peru.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Nov. 27, 1922	Dec. 4, 1922
Pool 1,	New York	$5.00-5.25	$5.00-5.50
Smokeless,	Columbus	6.00-6.35	6.00-6.35
Clearfield,	Boston	3.25-4.00	3.25-3.75
Somerset,	Boston	3.50-4.25	3.50-4.25
Kanawha,	Columbus	3.25-3.50	3.25-3.50
Hocking,	Columbus	3.00-3.50	2.75-3.25
Pittsburgh No. 8	Cleveland	3.40-4.00	3.15-3.25
Franklin, Ill.,	Chicago	4.00-4.25	4.00-4.25
Central, Ill.,	Chicago	3.00-3.25	3.00-3.25
Ind. 4th Vein,	Chicago	3.75-4.00	3.75-4.00
West Ky.,	Louisville	2.00-2.50	2.00-2.50
Big Seam,	Birmingham	2.25-2.50	2.25-2.50
S. E. Ky.,	Louisville	3.50-4.00	3.10-3.75

FUEL OIL

New York—Dec. 7, Port Arthur light oil, 22@25 deg. Baumé, 4⅞c. per gal.; 30@35 deg.. 5⅛c. per gal., f.o.b. Bayonne, N. J.

Chicago—Dec. 1, for 24@26 deg. Baumé, 90c. per bbl.; 32@36 deg., 2⅞@3c. per gal. in tank car, f.o.b. Oklahoma refinery, or freight adjusted.

Philadelphia—Dec. 4, 26@28 deg. Baumé, Oklahoma, 95c.@$1.00 per bbl.; 30@34 deg.. Oklahoma (group 3). 2⅞@3c. per gal.; 16@20 deg. Seaboard, $1.35@$1.40 per bbl.

St. Louis—Nov. 27, f.o.b. Oklahoma 24@26 deg., 95c. per bbl.; 26@28 deg., $1 per bbl.; 28@30 deg., $1.05 per bbl.; Gas oil 32@36 deg., 2⅞@3c. per gal.; 36@40 deg., distillate, 3½@3¾c. per gal.

Pittsburgh—Nov. 27, f.o.b. refinery, Penn., 36@40 deg., 5½@5¾c. per gal.; Kentucky, 26@30 deg., 4c.; Diesel, 3¼c.; Gas oil, 32@36 deg., 2½@2¾c.; 36@38 deg., 2½@3c.; 38@40 deg., 2¾@3¼c. per gal.; Western, 24@30 deg., 90c.@$1.05 per bbl.

Cincinnati—Nov. 27, for 26@28 deg., Baumé, 1¼c. per gal.; 28@30 deg., Diesel, 5¾c.; 38@40 deg., distillate, 6¼c. per gal.

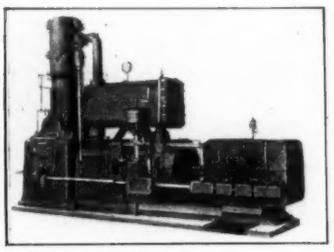
Cleveland—Nov. 27, for 26@28 deg., Baumé, 4¾c. per gal.

Condensed-Clipping Index of Equipment

Condensed from previous descriptions in "Power" for convenient filing

Compressor, Air "Power," 1922

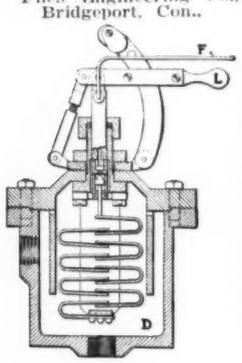
Sullivan Machinery Co., Chicago, Ill.



An angle-compound, steam-driven unit with a single horizontal steam cylinder placed tandem with the low-pressure air cylinder. The steam cylinder is of the high-duty, direct-flow type, in which the steam travels in a direct path from the two admission valves, one at each end of the cylinder, to the two exhaust valves near the center. Poppet valves of the wafer type are used; they all lie in the same horizontal plane and are driven from the same camshaft. At present the compressor is being built in two sizes, to handle 1,200 and 1,800 cu.ft. per min., respectively. Further described on page 330 of "Power" for Aug. 29, 1922.

Control, Temperature "Power," 1922

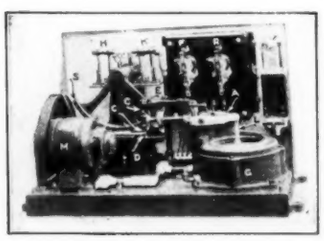
Files Engineering Co., Inc. (Temperature Control Division), Bridgeport, Con.



A temperature regulator whose action depends upon (1) a metallic thermostat consisting of a series of U-shaped elements as shown, and (2) a diaphragm mounted on the stem of the steam admission valve (not shown). The controlled fluid circulates in chamber *D* around the thermostat, whose upper end is attached to a small valve controlling the steam pressure in the feeler pipe *F*, which communicates with a chamber over the diaphragm. Temperature variations in chamber *D* cause pressure changes in feeler pipe *F*, which operate to open or close the steam valve by means of the diaphragm. Further illustrated and described on page 500 of "Power" for Sept. 26, 1922.

Control, Automatic Damper "Power," 1922

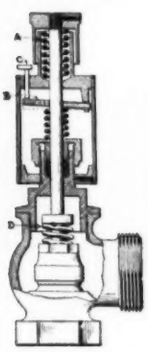
Northwestern Manufacturing Co., Milwaukee, Wis.



A regulator for automatically maintaining constant draft pressure, within 0.01 in. water column. Variations of this amount—or greater—cause the regulator to open or close the damper as much as is necessary. The essential working parts are the gasometer *G*, balanced arm *A*, motor *M*, contacts *CC*, *H* and *K* worm and sector *S* and forward and reverse contactors *F* and *R*. Sensitiveness of action is obtained through the use of a relay circuit which actuates the contactors when either contact *C* is made. The damper connection is on the rear end of the sector shaft (not shown). The device may also be used to control stoker speed. Further described on page 289 of "Power" for Aug. 22, 1922.

Valve, Foot-Operated Radiator "Power," 1922

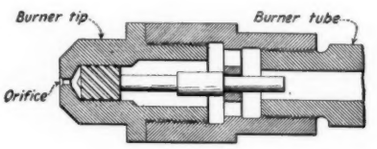
P. A. Riccio, 4547 Park Ave., New York City.



A radiator valve that may be adjusted to any position by a touch of the foot, instead of by turning a hand wheel. Normally, the spring *A* keeps the valve open; to close it, press down the cap with the foot as far as is desired; the hardened tool-steel piece *B* grips the stem in any position. To release the valve, press the small catch *C*, which releases the grip of *B* and allows the stem to rise. The spring *D* forces the valve tightly down on its seat when it is desired to shut off the steam entirely. Further described on page 162 of "Power" for Aug. 1, 1922.

Burner, Mechanical Oil "Power," 1922

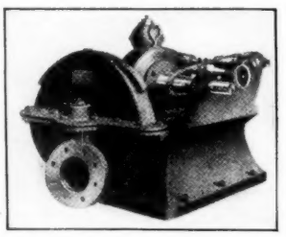
Schutte & Koerting Co., Philadelphia, Pa.



A mechanical burner in which rotation of the oil is obtained by forcing it through a screw with steeply pitched grooves, as shown. The oil is discharged in a conical spray. Oil pressures of from 125 to 250 lb. per sq.in. may be used. Draft may be either forced or natural; air is admitted through an adjustable conical register and is given a swirling motion by a set of baffles set at an angle to the air openings. Further described on page 95 of "Power" for July 18, 1922.

Turbine, Stoker Drive "Power," 1922

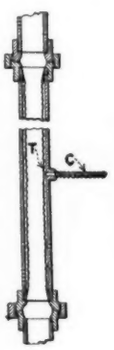
London Steam Turbine Co., Troy, N. Y.



A governor-controlled turbine for stoker drive designed to give high torque at low speeds. In case of an obstruction in the stoker, the governor valve immediately opens wide, thus giving full steam pressure behind the jets and preventing stalling. The governor is driven through a cone-and-belt, variable-speed transmission. The speed range obtainable at the main drive shaft is 100 to 400 r.p.m. A set of extra-large, hand-controlled auxiliary nozzles provides additional power for starting up a new, stiff stoker or for use in case of extremely low pressures. Further described on page 567 of "Power" for Oct. 10, 1922.

Thermostat, Pipe "Power," 1922

H. J. C. Wells, 620 Riverside Drive, New York City.



A temperature regulator in the form of a double-walled pipe section *T*, used to control the flow of steam for industrial heating. The fluid whose temperature is being controlled circulates through the pipe; a volatile liquid or sensitive oil fills the space between the pipe walls and communicates through the capillary tube *C* with the usual expansion element, which in turn controls the steam valve. The inner surface of the jacketed tube is shown corrugated, but it may be plain, if desired. The device may also be used to control the cooling-water systems of air compressors and gas and oil engines and to control temperature and humidity in dry kilns. Further described on page 353 of "Power" for Sept. 5, 1922.

Nozzle, Involute Spray "Power," 1922

Yarnall-Waring Co., Chestnut Hill, Philadelphia, Pa.

A spray nozzle having no internal parts, vanes or deflecting plates. The spray chamber is of involute form, as shown. Both single and double nozzles are made; the single nozzle is shown herewith. The double nozzle has two chambers and openings. With 2-in. pipe connections and 7 lb. pressure, the single nozzle will deliver 30 gal. per min. while the double nozzle will handle 47 gal. The nozzle was invented by W. H. Klein, superintendent Dixie Portland Cement Co., Richard City, Tenn. Further described on page 319 of "Power" for Aug. 29, 1922.

For a permanent file of new and improved power-plant equipment, clip and paste on 3 x 5-in. cards. (Patented Aug. 20, 1918.)

New Plant Construction

PROPOSED WORK

Ala., Florence—The U. S. Engineer Office, will receive bids until Dec. 30 for the construction and delivery of a 15 in. dredging pump for dredge Pettus.

Calif., Colton—The Bd. of Trustees plans to purchase three 200 hp. transformers to replace 3 of the six 100 hp. now in use, at the municipal electric light plant.

Calif., Los Angeles—R. J. Fleming, 506 Bryson Bldg., (representing owners), is in the market for pump for drainage purposes, capacity 2,000 gal. per min., extreme life 12 ft.

Calif., Orange—N. T. Edwards is in the market for ice making machinery.

Calif., Porterville—The Acme Ice Cream Co., 1313 Sansome St., San Francisco, has purchased a creamery plant, here and plans to remodel same and construct additions including an ice plant.

Calif., Taft—The Conley School Dist., P. Cornelius, Clk., will receive bids until Dec. 15 for furnishing and installing a refrigeration plant for school.

Col., Denver—H. W. Bennett, 1010 16th St., and associates have purchased the Braun Palace Hotel on 17th St. and Bway. and plan to remodel same, including the construction of 2 additional stories. Estimated cost $500,000. Architect not selected.

Fla., Ocala—The Marion County Ice Co. is in the market for electrical ice making machinery.

Ill., Chicago—The Ford Motor Co., Highland Park, Mich., plans the construction of a 1 story 502 x 1,363 ft. assembly plant and a 100 x 100 ft. power plant, including complete heating plant equipment, on Torrance Ave. A. Kahn, 1000 Marquette Bldg., Detroit, Mich., Archt. Owner is in the market for equipment consisting of conveyors, transferring and assembling machinery.

Ill., Chicago—D. S. Klafter, Archt., 64 W. Randolph St., is having plans prepared for the construction of a 3 story, 145 x 200 ft. store, office and hall building, including steam heating system, on Milwaukee and Agatite Aves. Estimated cost $500,000. Owner's name withheld.

Ill., Stockton—The city, W. G. Sieman, Clk., plans improvements to water supply, including installation of more economical pumping machinery and equipment. Estimated cost, $15,000. W. G. Kuchaffer, Dean Bldg., Madison, Engr.

Ind., Indianapolis—The Bd. of Sanitary Comrs., J. A. Craven, Pres., will receive bids until Dec. 28 for furnishing and erecting mechanical equipment of Sect. 4, Div. 3, for sewage disposal plant as follows; (a) c.i. pipe and specials, (b) low pressure gate valves, (c) power plant piping, (d) standard and high pressure valves, (e) air washing equipment, (f) electric centrifugal pumping units, (g) electric wiring and fixtures, (h) rotary dryers, stokers and conveying machinery, (i) sludge filters, C. H. Hurd, 1405 Merchants Bank Bldg., Consult. Engr. Noted Oct. 31.

Kan., Wichita—O. S. Shirk, 805 Schweiter Bldg., plans the construction of a 100 x 140 ft. family hotel, including steam heating system on Topeka and 2nd Sts. Estimated cost $250,000. Architect and Engineer not selected.

Ky., Louisville—J. G. Brown, having plans prepared for the construction of a 600 room hotel. Estimated cost $2,000,000. P. J. Bradshaw, Intl. Life Bldg., St. Louis, Mo., Archt.

La., Lafayette—The Bd. Trustees, A. Mouton, Mayor, plans the construction of an electric light and waterworks plant. Bids have been taken for the sale of $144-000 bonds.

Mass., Gloucester—The Savoy Dye House is in the market for additional machinery, including extractors, motors, etc. (used), for laundry and dye house.

Mich., Detroit—The Detroit Public Lighting Com., F. Misterske, Supt., East Atwater St., plans the construction of a 56 x 82 ft. substation, including the installation of transformers, heating boiler and ventilating unit on Woodward Ave. Smith, Hinchman & Crylls, 800 Marquette Bldg., Engrs.

Mich., Kalamazoo—The city, C. Miller, Mgr., City Hall, plans the construction of a 7 story, 66 x 198 ft. city hall on Burdick St. Estimated cost $1,500,000. Architect not selected.

Minn., Northfield—St. Olaf's College, P. O. Hann, Bus. Mgr., is having plans prepared for a power house. Estimated cost $50,000. J. D. Small, 127 North Dearborn St., Chicago, Ill., Engr.

Mo., Joplin—The Commercial Chat Co., 206 West 3rd St., A. G. Taubert, Purch. Agt., is in the market for 12 to 15 hp. oil engine, 40 hp. boiler, 48 in. screen and 16 in. elevator for power equipment.

Mo., St. Louis—The Bd. of Pub. Service, 208 City Hall, will receive bids until Jan. 2 for the construction of a 2 story, 54 x 225 ft. service building and power plant in connection with the Training School for Feeble Minded at Scott Farm. Estimated cost $150,000. L. R. Bowen, 304 City Hall, Archt. and Engr. Owners will be in the market later for two 200 hp. oil burning, water tube boilers, 2½ ton ice plant and a 10 ton refrigeration plant. Noted Oct. 10.

Mo., St. Louis—E. R. Eddins, 4542 A McMillan Ave., is in the market for a steam boiler for 800 ft. radiation.

Neb., Clay Center—The city, J. E. Ray, Clk., will receive bids until Dec. 13, for the construction of a complete sewerage system including sewage disposal plant consisting of settling tank, trickling filters, pumping station, etc. Estimated cost $64,400. Grant, Fulton & Letton, 505 Bankers Life Bldg., Lincoln, Engrs.

N. J., Trenton—The Bd. Educ. will soon receive bids for the construction of a school on Dayton St. Estimated cost $1,000,000. E. Sibley, Edgewood Lane, Palisade, Archt. Equipment detail not reported.

N. J., Trenton—The city plans the construction of the first unit of a group of buildings to be known as the Central High School. Estimated cost $300,000, total cost $1,000,000. E. Sibley, Edgewood Lane, Palisade, Engr.

N. Y., Buffalo—The Culliton Ice Cream Co., 172 Guilford St., has had plans prepared for the construction of a 1 story, 65 x 80 ft. ice plant, 30 x 65 ft. engine room and 30 x 60 ft. ice storage room, on Jewett Ave. Estimated cost to exceed $35,000. Architect not announced. Noted Nov. 28.

N. Y., Leroy—The Union Explosives Co., plans to rebuild power house on Gulf Rd., recently destroyed by fire. Owner is in the market for boilers, pumping outfit and other machinery.

N. Y., New York—The Bd. Educ., 500 Park Ave., will soon receive bids for the construction of a 4 story, 300 x 300 ft. George Washington High School on 183rd St. and Amsterdam Ave.; also a 5 story P. S. 11 on 20th St. Estimated cost $1,750,000 and $1,000,000 respectively. C. B. J. Snyder, Concord St. and Flatbush Ave. Ext., Bklyn., Archt. and Engr. Steam heating systems will be installed.

N. Y., Rochester—The Eastman Kodak Co., Kodak Park, is in the market for refrigeration plant machinery and equipment.

N. Y., Rochester—The Empire State Co., Chicago, Ill., has had plans prepared for the construction of a 48 x 182 ft. and 67 x 133 ft. ice manufacturing and storage plant on Atlantic Ave., here. Estimated cost $300,-000. Owner is in the market for $225,000 worth of ice and refrigeration machinery.

N. Y., Tupper Lake—The Bureau of Yards & Docks, L. E. Gregory, Chf., Navy Dept., Wash., D. C., will receive bids until Dec. 28 for the construction of U. S. Veteran's Hospital, here as follows; Part 1, twelve new buildings and remodeling existing residence; Part 2, plumbing work inside buildings; Part 3, complete heating and steam distributing system for each building and an outside steam distributing system, including high pressure and vacuum return lines, hot water heaters, etc.; Part 4, lighting systems for each building, nurses call system, power systems and telephone conduits in certain buildings, outside electric distributing systems, including transformers, panel boards, fixtures, conduits, fibre ducts and wiring; Part 5, boiler plant equipment and piping, including brick settings for return tubular boilers, smoke flue, feed water heater, storage tank, feed water and vacuum pumps, combined twin pump and receiver, drip traps, incinerator with hot water heating and sterlizing equipment, complete piping systems for all apparatus, and the installation of horizontal return tubular boilers furnished by the Government, Spec. 4718. Noted Nov. 28.

N. Y., White Plains—The Dentermann & Son Ice Co., plans the construction of a 1 story, 50 x 120 ft. addition to its ice plant. Estimated cost $65,000. L. Block, 501 5th Ave., New York, Engr.

N. C., Murphy—W. V. N. Powellson, Pres. of the Carolina-Tennessee Power Co., Murphy, is interested in a power development project on the Hiwassee River, in Cherokee County. Plans include the construction of 2 large dams and 2 generating stations to generate 60,000 hp. Estimated cost $5,000,000. Engineer not announced.

N. C., Raleigh—The Carolina Power & Light Co., P. A. Tillery, Vice-Pres. and Gen. Mgr., plans improvement and expansion of its properties, including additions to various plants, substations, transmission lines, steam plants, equipment, etc. Estimated cost $6,000,000.

Ohio, Akron—The city council plans the construction of a new city hall on South High St. Estimated cost $900,000. Architect not selected. A bond issue for the above amount was approved by voters in April, 1920.

Ohio, Cleveland—The Chester-Twelfth Co., c/o C. H. Quinlin, Swetland Bldg., is having plans prepared for the construction of a 12 story, 130 x 130 ft. commercial and office building, including steam heating system on East 12th and Chester Sts. Estimated cost $1,000,000. W. S. Ferguson Co., 1900 Euclid Ave., Archts. Noted April 11.

Ohio, Cleveland—The city received bids for the construction of a 30 x 35 ft. pumping station and substructures on Lake Shore Blvd., from the Western Reserve Constr. Co., 2244 Murray Hill Rd., $21,000, D. Lowensohn, 12603 Clifton Blvd., $25,913, Rice Jones Co., 1836 Euclid Ave., $27,020. Private plans.

Ohio, Cleveland—The J. J. Masterson Co., 1102 Scovill Ave., is in the market for a 15 hp. electric motor.

Ohio, Cleveland—The Sisters of the Good Shepherd, East 30th St. and Carnegie Ave., is having plans prepared for the construction of a 4 story Convent school and power plant on Euclid Line. Estimated cost $350,000. H. Koehl, Park Bldg., Archt.

Ohio, Columbus—The Federal Ice & Refrigeration Co. has had plans prepared for the construction of a 1 story, 40 x 155 ft. cold storage plant on 20th St. Estimated cost $150,000. C. C. Conehy, Cadillac Bldg., Cleveland, Archt. and Engr. Equipment detail not reported.

Ore., Portland—The See-Der Mfg. Co., S. A. Marnotte, Mgr., plans the construction of a factory for the manufacture of cedar chests, furniture and wood novelties. Estimated cost $25,000. Owner is in the market for 60 hp. boiler and engine, belting, shafting, etc.

Pa., Allentown—V. B. Boyer, 242 North 11th St., is in the market for refrigeration machinery, cold storage and abbatoir equipment.

Pa., Butler—E. L. Tilton, Archt., 121 East 45th St., New York, received bids for the construction of a 3 story hospital on Brady St., (a) main building, (b) power house, from the W. M. Sutherland Constr. Co., Commerce Bldg., Erie, (a) $414,827, (b) $74,763; Cuthbert Bros., Bessemer Bldg., Pittsburgh, (a) $427,149, (b) $73,758; Amsterdam Bldg. Co., 138 East 44th St., New York, (a) $442,287, (b) $75,086. Noted Oct. 31.

Pa., Johnstown—The Penn. Public Service Co., plans to increase its capital stock for improvements and additions to lines and plants at Armagh, Confluence, Boswell and Lumber City.

Pa., Juniata—The Pennsylvania System-Eastern Region, Phila., is having plans prepared for the construction of a 45 x 150 ft. power house, here. A. C. Shand, Broad St. Sta., Phila., Engr.

Pa., Kittanning—The Armstrong County Community Hospital is having preliminary plans prepared for the construction of a hospital and power house. Estimated cost $250,000. Crow, Lewis & Wick, 200 5th Ave., New York, Archts.

Pa., Lancaster—The Bershire Electric Co. plans to vote $59,000 bonds to be used for extensions and improvements to plant and lines.

Pa., Phila.—The Bd. Pub. Health, 516 City Hall, plans additions to heating system and the construction of tunnels for same, at the proposed Byberry Hospital on Byberry Ave. Estimated cost $160,000. P. H. Johnson, 1716 Sansom St., Archt. Noted Sept. 12.

Pa., Phila.—The Franklin Institute, 15 South 7th St., will soon receive new bids for the construction of a 4 story, 57 x 110 ft. electric laboratory on 19th and Cherry Sts. J. T. Windrim, Commonwealth Bldg., Archt. Former bids rejected. Equipment detail not reported.

Tex., Corpus Christi—The city is having plans prepared for the construction of electric light and power plant. Estimate cost $25,000. C. J. Howard, Engr.

Tex., Laredo—R. W. Morrison plans the construction of a new power dam, 30 ft. high, 5 mi. from here, to develop about 5,000 hp.

Va., Alexandria—The Herfurth Engine & Machinery Co., is in the market for 300 ft. 3 lb. air blower, 75 to 100 hp. oil engine, 7½ x 7½, 9 x 9 and 10 x 10 ice machines, belt driven, enclosed type, (used).

Va., Fredericksburg—W. B. Jenkins, 65 Princess Anne St., is in the market for a 25 cycle motor, single phase, 110 volt a.c.

Wash., Cheney—The city will receive bids in the spring for drilling well 625 ft. deep, casing, pump, engine, housing, etc. Estimated cost $13,000. Engineer not selected.

Wis., Green Bay—Hotel Wisconsin, W. Schroeder, Pres., 86 Michigan St., Milwaukee, plans the construction of a 9 story, 130 x 160 ft. hotel on Adams St., here. Estimated cost $850,000. M. Tullgren & Sons Co., 425 East Water St., Milwaukee, Archt. Noted Nov. 8.

Wis., Madison—The Hotel Madison Co., E. Clarenboch, Pres., c/o Stanley C. Hanks Co., First Central Bldg., is having plans prepared for the construction of a 6 story 250 room hotel, including steam heating system. Estimated cost $1,000,000. C. Barkhousen, 79 Wisconsin St., Milwaukee, Archt.

Wis., Madison—The University of Wisconsin, M. E. McCoffery, Secy., plans the construction of 4 and 6 story dormitories on Park St. Estimated cost $600,000. Architect not selected.

Wis., Milwaukee—P. Hoff, 64 Locust St., is in the market for electrically driven ice making machinery.

Wis., Racine—The Racine Pure Milk Co., 1010 13th St., is receiving bids for a 26 x 46 ft. boiler house. Estimated cost $10,000. Cahill & Douglas, 217 West Water St., Milwaukee, Engrs. Contract for boilers awarded to S. Freeman & Sons Mfg. Co. Noted Nov. 7.

Wis., Random Lake—The Krier Preserving Co., Belgium, is receiving bids for the construction of 1 and 2 story, 50 x 240 ft. cannery, including main factory building, warehouse, sheds and power house. Estimated cost $100,000. Private plans. Owner is in the market for canning machinery, belting, shafting, power equipment including boilers, engine, pumps and steel stack.

Alta., Coleman—The International Coal & Coke Co., Ltd., is in the market for complete power house and boiler room machinery, also plant to replace one destroyed by fire.

Man., Brandon—The Canada Gas & Electric Corp., J. B. Harvey, Gen'l. Mgr., is in the market for one 1,500 kw. hydro-electric unit under a 50 ft. head, three 350 hp. boilers equipped with furnaces, etc. for burning lignite screenings. Will be in the market later for new substation equipment.

B. C., Esquimalt—The Dept. Pub. Works, R. C. Desrochers, Secy., Ottawa, Ont., will receive bids until Jan. 15 for the construction and installation of pumping and other machinery for the Dry Dock here. Estimated cost $50,000.

B. C., South Vancouver—The British Columbia Electric Ry., Hastings and Carroll Sts., is receiving bids for an automatic rotary substation on Bodwell Rd., capacity of plant 1000 kw., 34,600 a.c. to 550 d.c., 3 phase, 60 cycle. Estimated cost $60,000. J. T. Newell, 325 Carroll St., Elec. Supt.

B. C., Vancouver—Adkison & Dill, 325 Howe St., has been granted franchise by the city council to build central heating plant and distributing system to burn lumber mill waste. Noted Sept. 19.

Ont., Fort Erie—The city plans the construction of about 10 mi. of new sewer piping. Work will include electrical force pump and gravitation system. Estimated cost $215,000. W. C. Redfern, c/o James, Proctor & Redfern, Excelsior Life Bldg., Toronto, Engr.

Ont., Mount Dennis—The Electroplax Mfg. Co., plans to rebuild electroplating factory recently destroyed by fire. Estimated cost $100,000. Owner is in the market for electric plating equipment.

Ont., Wheatley—The city council, M. H. Chamberlain, Clk., plan new electric lighting system and power distribution plant. Want prices and information on same. Estimated cost $35,000.

Que., Montreal—O. Beaudouin, 71A St. James St. W., is in the market for a 350 U. S. g.p.m. centrifugal pump, 85 ft. head direct connected to 15 hp. motor, single phase, 220 volt.

Que., Montreal—The city, R. Bauset, Clk., received bids for the construction of the distribution control building for the new pumping station on Atwater Ave. from E. G. M. Cape & Co., Cathcart St., $167,000; Quinlan, Robertson & Canin Co., 52 Duluth Bldg., $167,700; John Quinlan Co., Green Ave., $170,307.

Que., Quebec—The Quebec Development Co., c/o W. L. Lee, Engr., 511 5th Ave., New York, plans hydroelectric development along the Saguenay River. Estimated cost $1,000,000.

Every one of these items is reported by our authorized correspondents who are instructed to verify every item sent in. This free weekly service is published in the interests of the buyer and the seller, to bring them together and get machinery moving.
Everything possible is done to insure authenticity and timeliness.
Your co-operation is invited in helping us maintain this service at the highest efficiency.

BUSINESS NEWS DEPARTMENT
Tenth Ave. at 36th St., New York

CONTRACTS AWARDED

Ill., Chicago—S. W. Straus & Co., 565 5th Ave., New York, awarded the contract for the construction of a 22 story, 161 x 171 ft. bank and office building on Michigan and Jackson Blvds., here, to the Thompson-Starrett Constr. Co., Insurance Exchange Bldg. Estimated cost $7,000,000. Equipment detail not reported.

Ind., Terre Haute—The Indiana Electric Corp., c/o Kelsey, Brewer & Co., Grand Rapids Savings Bank Bldg., Grand Rapids, Mich., awarded the contract for a 40,000 kw. steam electric power station, ultimate capacity 100,000 kw., on the west bank of the Wabash River about four mi. from here, to Stone & Webster, 147 Milk St., Boston, Mass.

Kan., Wichita—The Jacob Dold Packing Co., 21st St. and Lawrence Ave., awarded the contract for the construction of a refrigeration plant to the Carbondale Refrigeration Co., Carbondale, Pa. Estimated cost $100,000. Owner is in the market for refrigeration equipment.

N. Y., New York—The Gairo Realty Co., c/o G. F. Pelham, archt. and engr., 200 West 72nd St., will build by day labor, a 14 story, 75 x 80 ft. apartment building at 159 West 54th St. Estimated cost $600,000. Equipment detail not reported.

N. Y., New York—The Gold Cross Constr. Co., c/o E. M. Crumley, archt. and engr., 355 East 149th St., will build a 5 story, 65 x 150 ft. apartment building on Union Ave., by separate contracts under supervision of the architect. Estimated cost $750,000. Equipment detail not reported.

N. Y., New York—The S & L Building Corp., c/o E. Roth, Archt. and Engr., 119 West 40th St., will build by day labor, a 14 story, 102 x 142 ft. apartment building on 82nd St. and Bway. Estimated cost $1,200,000. Steam heating system will be installed.

N. Y., Rochester—The city and University of Rochester, University Ave., will build a 100 bed, municipal hospital, including boiler room. Estimated cost $500,000. Architect not announced. C. A. Poole, City Engr.

N. Y., Sheepshead Bay—The Superior Ice Co., Inc., 50 East 42nd St., New York, will build an ice plant on East 17th St. and Avenue Z, here, by separate contracts under the supervision of the architect. Estimated cost $250,000. Equipment detail not reported. Noted Nov. 28.

Ohio, Cleveland—The Broadway Properties Co., c/o G. R. McKay, Associate Investment Co. Guardian Bldg., awarded the contract for the construction of a 1 and 2 story, 193 x 213 ft. commercial and market house on Cable Ave. and Bway., to the C. T. Minnick Constr. Co., 701 Guardian Bldg. Estimated cost $500,000. Steam heating system will be installed. Noted Nov. 22.

Ohio, Cleveland—The Bd. Educ., F. G. Hogen, Dir., awarded the contract for the construction of a 2 story, 160 x 300 ft. school on East 140th St. and Darley Ave., to the Tenbusch-Parker Constr. Co., Union Bldg., $364,890, heating to Feldman Bros., 10309 Barrett Ave., $55,425. Noted Nov. 7.

Ohio, Cleveland—The Miramer Development Co., c/o J. H. MacDowell, Archt., 510 Bulkley Bldg., awarded the contract for the construction of a 6 story apartment building on Blount St. and Detroit Rd., to the Wm. Dunbar Co., 8201 Cedar Ave. Estimated cost $1,000,000. Steam heating system will be installed.

Ohio, Cleveland—The Tifereth Israel Congregation, c/o L. M. Wolf, Hickox Bldg., Chn. Bldg. Com., awarded the contract for the construction of a 2 and 4 story temple and school on East 105th St. and Ansel Rd., to John Gill & Sons, Citizens Bldg. Estimated cost $1,000,000. Steam heating system will be installed. Noted July 4.

Pa., Phila.—The Bd. Pub. Health, City Hall, awarded the contract for the construction of a 4 story hospital on 34th and Pine Sts. to the J. B. Kelley Co., 2313 Walnut St., $246,987. Equipment detail not reported.

Tenn., Memphis—The Fischer Heating Co., 51 South 3rd St., awarded the contract for the construction of a steam and hot water plant also machine shop on Adams Ave., to R. F. Creson & Son, Turley Bldg. Estimated cost $35,000.

Tenn., Memphis—The Memphis Artesian Water Co. awarded contracts as follows: Contract 7, superstructures, chimney and filter equipment to Gauger-Korsmo Co., 301 Endicott Bldg., St. Paul, Minn., $474,815; Contract 8, coal and ash handling system, Link-Belt Co., 910 South Michigan Ave., Chicago, Ill., $26,800; Contract 9, secondary pumping unit, Worthington Pump & Machinery Corp., 115 Bway., New York, $8,700; Contract 10, two 100 kw. direct connected unaflow engine generator sets and switchboard, Chuse Engine & Mfg. Co., Memphis, $22,272. Noted Oct. 31.

Wash., Seattle—The Simpson-Wilson Co., University Way, awarded the contract for the construction of a 6 story, 103 x 144 ft. apartment hotel on 47th and University Way, to the Puget Sound Bridge & Dredging Co., Central Bldg. Estimated cost $750,000. Equipment detail not reported.

Wis., Eau Claire—The Lang Canning Co., Mill St., will build by day labor, additional buildings including a 2 and 3 story main factory, viner and husking buildings, garage and boiler room, etc. Estimated cost $120,000. Private plans. Canning machinery, belting and shafting will be installed.

Wis., Milwaukee—The Random Lake Ice Co., 064 Locust St., will build by day labor, a 100 x 125 ft. ice manufacturing plant on Walnut St. Estimated cost $50,000. G. B. Bright Co., Marquette Bldg., Detroit, Mich., Engr., is in the market for 96 ton ice making machinery.

Wis., Neenah—The Kimberly-Clark Co., awarded the contract for the construction of a 2 story, 65 x 120 ft. paper mill to C. R. Meyer & Sons Co., 50 State St., Oshkosh. Estimated cost $65,000. Electric power machinery will be installed.

Bermuda, Hamilton—The Hamilton Hotel Corp., awarded the contract for the construction of a 6 story, 200 x 250 ft. hotel, to the James Stewart Co., 30 Church St., New York. Estimated cost $1,000,000. Equipment detail not reported.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

Advances—Average rise of 50c. per ton on chrome brick at Eastern shipping points; chrome cement up $2@$3 per ton, since last month. Chrome ore, crude, quoted at range of $20@$22 as against $21 per ton, one month ago. Babbitt metal, all grades, up ¼c.@2c. per lb., in Cleveland warehouses. Steam hose and rubber belting discounts slightly higher; leather belting firm.

Declines—Fire hose, 2½-in., coupled, 45c. as compared with 49½c. per ft., last month. Linseed oil, raw, 90c. in New York as against 93c. per gal. (5-bbl. lots) one month ago. Structural and boiler rivets down about 15c. per 100 lb., f.o.b. Pittsburgh. Sharp declines in magnesite brick during month.

POWER-PLANT SUPPLIES

HOSE—

	Fire	50-Ft. Lengths
Underwriters' 2½-in., coupled		45c. per ft.
Common, 2½-in., 3-ply	1.00 per ft. list less 50%	

	Air	
	First Grade	Second Grade
¾-in., 3-ply, per ft.	$0.31	$0.22½

Steam—Discounts from List		
First grade....40-10-5%	Second grade....50	Third grade....50-10

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition	65%	Best grade	60%

LEATHER BELTING—List price per ply, 12-in. wide, per lin. ft. $2.88

Grade	Discount from list
Medium	30-10%
Heavy	20-5-2½%

RAWHIDE LACING—For cut, best grade, 40%, 2nd grade, 50%. For laces in sides, best, 48c. per sq.ft.; 2nd, 43c. Semi-tanned: cut, 40%; sides, 48c. per sq.ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam, ⅛ in	$0.90
Asbestos for high-pressure steam, ½ in	1.80
Duck and rubber for piston packing	.90
Flax, regular	1.10
Flax, waterproofed	1.70
Compressed asbestos sheet	.90
Wire insertion asbestos sheet	1.30
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.40
Asbestos wick, ½- and 1-lb. balls	.70

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		40 & 45% off
For low-pressure heating and return lines	4-ply	60% off
	3-ply	62½% off
	2-ply	65% off

PORTLAND CEMENT—New York, $2.60 per bbl. without bags, in cargo lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.14 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York Current	Cleveland	Chicago
White	9.00@11.50	12.00	11.25
Mixed	6.50@10.00	9.00	8.00

WIPING CLOTHS—Jobbers' prices, in cents per lb., as follows:

	13¼ x 13¼	13¼ x 20½
Chicago	10.00	13.00
New York	16.00	20.00
Cleveland	$32.00 per M.	$48.00 per M.

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$0.90	$1.01	$0.95

WHITE AND RED LEAD—Base price in cents per pound:

	Red				White			
	Current		1 Year Ago		Current		1 Yr. Ago	
	Dry	In Oil	Dry	In Oil	Dry or In Oil		Dry or In Oil	
100-lb. keg	13.25	14.75	12.25	13.75	13.25		12.25	
25- and 50-lb. keg	13.50	15.00	12.50	14.00	13.50		12.50	
12½-lb. keg	13.75	15.25	12.75	14.25	13.75		12.75	
5-lb. cans	16.25	17.75	15.25	16.75	16.25		15.25	
1-lb. cans	18.25	19.75	17.25	18.75	18.25		17.25	

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅞ and smaller	45%	60%	60%
Tinned	50%	60%	4½c. per lb. net

Structural rivets, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.
New York....$3.85 Chicago....$3.75 Pittsburgh....$3@3.15
Boiler rivets, same sizes:
New York....$3.95 Chicago....$3.85 Pittsburgh....$3.10@3.25

REFRACTORIES—Prices in car lots:

Chrome brick, eastern shipping points	net ton	$50@55
Chrome cement, 40@50% Cr_2O_3	net ton	27@30
Chrome cement, 40@50% Cr_2O_3, in sacks	net ton	31@34
Magnesite brick: 9-in. shapes	net ton	70@75
Magnesite brick: 9-in. arches, wedges and keys	net ton	77@82.50
Magnesite brick: Soaps and spits	per ton	98@105
Silica brick: Chicago district	per 1,000	53.00
Silica brick: Birmingham, Ala	per 1,000	52.00
Silica brick: Mt. Union, Pa	per 1,000	46.00
Clay brick, 1st quality, 9-in. shapes, Missouri	per 1,000	40@45
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per 1,000	38.00
Clay brick, 1st quality, 9 in. shapes, Ohio	per 1,000	38.00
Clay brick, 1st quality, 9 in. shapes, Kentucky	per 1,000	38.00
Clay brick, 2nd quality, 9-in. shapes, Missouri	per 1,000	30@35
Clay brick, 2nd quality, 9 in. shapes, Pennsylvana	per 1,000	34.00
Clay brick, 2nd quality, 9 in. shapes, Ohio	per 1,000	34.00
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per 1,000	34.00
Chrome ore crude, 45@50%	net ton	20@22
Magnesite dead burn	net ton	24.00

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
(83% tin)	35.00	47.00	36.00
(35% tin)	25.00	17.50	.....

COLD FINISHED STEEL—Warehouse prices are as follows:

	New York	Chicago	Cleveland
Round shafting and screw stock, per 100 lb. base	$3.90	$3.70	$3.75
Flats, square and hexagons, per 100 lb. base	4.40	4.20	4.25

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	60-10%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	55%
Pressed steel boiler lugs	10%
Pressed steel boiler hangers	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the latest Pittsburgh basing card:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv
1 to 3	66	54½	⅜ to 1½	34	19

LAP WELD

2	59	47½	2	29	15
2½ to 6	63	51½	2½ to 4	32½	19
7 to 8	60	47½	4½ to 6	32½	19
9 and 12	59	46½	7 to 12	30	17

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	64	53½	⅜ to 1½	34	20
2 to 3	65	54½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	57	46½	2	30	17
2½ to 4	61	50½	2½ to 4	33	21
4½ to 6	60	49½	4½ to 6	32	20
7 to 8	56	43½	7 to 8	25	13
9 to 12	50	37½	9 to 12	20	

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$0.23
1¼	.....	.....	.25
1½	.....	.....	.22
1¾	$0.26	$0.29	.23
2	.20	.25	.21
2¼	.23	.29	.23
2½	.24	.33	.28
2¾	.....	.....	.....
3	.30	.41	.32
3¼	.32	.47	.35
3½	.34	.51	.37
4	.43	.64	.47

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per lineal foot based on stock lengths. If cut to special engths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

1¼ in. to 2 in. diameter, 5c. per cut. 2½ in. diameter, 7c. per cut
2¾ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3¼ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$ 44.00 (net)	$59.00(net)	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:		Lead Covered
Less than coil lots	35%	20%
Coils to 1,000 ft.	40%	25%
1,000 to 5,000 ft.	45%	30%
5,000 ft. and over	50%	35%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f. o. b. New York, with 10-day discount of 5 per cent.

Size, In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplgs Black Per C	Couplgs Galvanized Per C
¾	$55.59	$60.69	$9.96	$11.11	$4.52	$4.88
1	55.59	60.69	9.96	11.11	5.28	5.70
1¼	70.61	77.51	13.10	14.60	7.54	8.14
1	100.98	111.18	19.39	21.61	9.80	10.58
1¼	136.62	150.42	25.83	28.53	13.67	14.69
1½	163.35	179.85	34.44	38.04	16.88	18.14
2	219.78	241.98	63.14	69.74	22.51	24.19
2½	347.49	382.59	103.32	114.12	32.16	34.56
3	454.41	500.31	275.52	304.32	48.24	51.84
3½	574.08	629.28	608.44	672.04	64.32	69.12
4	701.96	767.36	703.15	776.65	80.40	86.40

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.08	D. P. D. B.	$0.26
D. P. M. L.	.13	T. P. S. B.	.25
T. P. M. L.	.19	T. P. D. B.	.38
D. P. S. B.	.15		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.38	$1.20	$1.25
T. P. M. L.	.53	1.40	1.80
D. P. S. B.	.47	1.20	.....
T. P. S. B.	.88	2.00	.....
D. P. D. B.	.85	2.35	.....
T. P. D. B.	1.50	4.00	.....
T. P. to D. P. D. B.	1.00	2.75	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy	$19.95
No. 16 cotton reinforced heavy	26.15
No. 18 cotton reinforced light	17.33
No. 16 cotton reinforced light	21.50
No. 18 cotton Canvasite cord	14.70
No. 16 cotton Canvasite cord	17.06

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.,	100	$.20	3-amp. to 30-amp.,	100	$0.40
35-amp. to 60-amp.,	100	.30	35-amp. to 60-amp.,	100	.60
65-amp. to 100-amp.,	50	0.90	65-amp. to 100-amp.,	50	1.50
110-amp. to 200-amp.,	25	2.00	110-amp. to 200-amp.,	25	2.50
225-amp. to 400-amp.,	25	3.60	225-amp. to 400-amp.,	25	5.50
425-amp. to 600-amp.,	10	5.50	450-amp. to 600-amp.,	10	8.00

Discount: Less 1-5th standard package, 55%; 1-5th to standard package, 60%; standard package, 65%.

RENEWABLE FUSES, ENCLOSED—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22½%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0–30 ampere, standard package	$2.50
0–30 ampere, less than standard package	2.85

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs or Bowl Enameled Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.35	$0.40	100	75	$0.60	$0.65	50
15	.35	.40	100	100	.75	80	24
25	.35	.40	100	150	1.00	1.10	24
40	.35	.40	100	200	1.30	1.40	24
50	.35	.40	100	300	1.90	2.00	24
60	.40	.45	100				12
				500	2.75	2.90	12
				750	4.00	4.25	8
				1.000	4.50	4.75	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.17
Composition 2-piece attachment plug	.26
Swivel attachment plug	.12

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York.

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$ 6.30	$ 8.00	$10.02	$15.96
12	8.72	10.60	12.54	20 84
10	11.44	13.65	15.96	27.09
8	15.38	17.90	21.05	36.22
6	.....	.....	31.81	.....
4	.....	.....	42.94	.....
2	.....	.....	64.99	.....
1	.....	.....	86.83	.....
0	.....	.....	107.78	.....
00	.....	.....	127.89	.....
000	.....	.....	153.66	.....
0000	.....	.....	183.70	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap — Key Each	Keyless Each	Pull Each	¾ In. Cap — Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0.60	$0.39	$0.36	$0 66

Less 1-5th standard package	15%
1-5th to standard package	27%
Standard package	42%

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb
Rubber tape, ¾ in., less 100 lb. 34c. lb., 100 lb. lots	33c. lb
Wire solder, less 100 lb. 27c. lb., 100 lb. lots	21c. lb
Soldering paste, 2 oz. cans	$1.00 doz

ENCLOSED SWITCHES, KNIFE—Externally operated, 250 d.c. or a.c., N.E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	25%
$25 to $50 list value	30%
$50 list value or over	35%